TECHNICAL PAPERS

REGIONAL
TECHNICAL CONFERENCE

"Auxiliary Equipment and Techniques In Plastics Processing"

OCTOBER 31 - NOVEMBER 1, 1968

Military Park Hotel
Newark, N. J.

SOCIETY OF PLASTICS ENGINEERS, INC. • NEWARK SECTION

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

-- 5 - CORPORATE AUTHOR: VIRGINIA POLYTECHNIC INST AND STATE UNIV
-- BLACKSBURG COLL OF ENGINEERING
-- 6 - UNCLASSIFIED TITLE: INTERLAMINAR STRESSES IN COMPOSITE
-TES--A PERTURBATION ANALYSIS,
*MSG DI4 DROLS PROCESSING-LAST INPUT IGNORED

-- 1 OF 1
-- ***DTIC DOES NOT HAVE THIS ITEM***
-- 1 - AD NUMBER: D423722
-- 5 - CORPORATE AUTHOR: SOCIETY OF PLASTICS ENGINEERS GREENWICH CONN*
-- 6 - UNCLASSIFIED TITLE: AUXILIARY EQUIPMENT AND TECHNIQUES IN
-- PLASTICS PROCESSING.
--11 - REPORT DATE: NOV 01, 1968
--12 - PAGINATION: 74P
--20 - REPORT CLASSIFICATION: UNCLASSIFIED
--21 - SUPPLEMENTARY NOTE: PROCEEDINGS: REGIONAL TECHNICAL CONFERENCE,
'AUXILIARY EQUIPMENT AND TECHNIQUES IN PLASTICS PROCESSING', 31 OCT
- 1 NOV 68, NEWARK, N.J. SPONSORED BY THE SOCIETY OF PLASTICS
-- ENGINEERS, NEWARK SECTION. (SEE PL-27477 - PL-27488).
--22 - LIMITATIONS (ALPHA): APPROVED FOR PUBLIC RELEASE; DISTRIBUTION
-- UNLIMITED. ~~AVAILABILITY: SOCIETY OF PLASTICS ENGINEERS, 656 PUTNAM~~
-- ~~AVE., GREENWICH, CT. 06830.~~
--33 - LIMITATION CODES: 1 [redacted]

-- END Y FOR NEXT ACCESSION END

Alt-Z FOR HELP3 ANSI 3 HDX 3 3 LOG CLOSED 3 PRINT OFF 3 PARITY

"AUXILIARY EQUIPMENT AND PROCESSING TECHNIQUES"

Regional Technical Conference

Sponsored by the

Newark Section

Society of Plastics Engineers, Inc.

October 31 - November 1, 1968

"AUXILIARY EQUIPMENT AND PROCESSING TECHNIQUES"

Regional Technical Conference of the Society of Plastics Engineers, Inc.

Sponsored by the

NEWARK SECTION

Newark, New Jersey

October 31 - November 1, 1968

Conference Committee

Chairman	Joseph J. Inserra	GAF Corp.
Program	Robert J. Boyden	Metropolitan Machinery Assoc.
Registration	Burton H. Krevsky	Union Carbide Corp.
Publicity	Philip D. Stokes	Plastics World Magazine
House	Ernest R. Pirro	Foster Grant
Treasurer	George F. Lillquist	Airco Chemicals & Plastics

Officers of the Newark Section

President	John L. O'Toole
Vice-President	William H. Meyer
Secretary	Alfred M. Johnsrud
Treasurer	John P. Lombardi
Councilman	Victor Q. Merrill

Papers edited for publication by John Hyden.

11673

TABLE OF CONTENTS

	PAGE
"Planning - Keystone to Material Conveying Success" Robert J. Munns, Whitlock, Inc.	1-01
"Automating the Dry Coloring Process" John C. Reib, Conair, Inc.	13 - dup. 8969-04
"Color Concentrates for Thermoplastics and Related Problems" Myles Z. Schneider, Ampacet Corp.	23 - 02
"Liquid Dyes and the Growing Color Market" Deran E. Altoonian, Patent Chemicals, Inc.	27 - 03
"Dehumidified Drying for Plastics" Dewey Rainville, Universal Dynamics Corp.	31 - 04
"Reynolds Number Analysis of Heat Transfer in the Mold" C. E. Waters, Application Engineering Corp.	37 - 05
"Mold Temperature Control - Heating" Joe D. Robertson, Process Control Corp.	42 - 06
"Automated Granulating Systems for Injection Molders" Fred M. Smith, Cumberland Engineering Co., Inc.	46 - 07
"Post Molding Decorating" Arthur N. Skeels, Sr., Decorama, Inc.	51 - 08
"Slitting, Winding and Rewinding" Andrew J. Rimol, John Dusenbery Co.	56 - 09
"Profile Extrusions" Charles Gatto, Gatto Machinery Development Corp.	61 - 10
"Trimming and Finishing Typical Polyethylene Blow-Molded Bottles" Robert A. Scheer, Brown Machine Co. of Mich., Inc.	65 - 11
"Scrap Recovery for Blow Molding" A. L. Maiocco, Beloit Corp.	70 - 12

STATEMENT OF POLICY

RELEASE FOR PUBLICATION

OF

CONFERENCE PAPERS

An SPE Conference is a forum for discussion of contributions to the scientific and engineering knowledge of plastics. Conference preprints aid communication between speakers and audience, encouraging meaningful discussion. They are not a substitute for publication.

Selected conference papers and discussions are added to the literature through publication by the Society, as in the SPE JOURNAL or POLYMER ENGINEERING AND SCIENCE. Others are released for publication elsewhere in accordance with the following policy.

1. All papers submitted to and accepted by the Society for presentation at one of its Conferences become the property of the Society of Plastics Engineers, Inc., and all publication rights are reserved by the Society.

2. By two weeks after the close of the Conference at which the papers are presented, the Society shall make known to the authors those papers selected to be considered for publication. All other papers are released to their authors with the stipulation that if they are published elsewhere, accompanying credit shall be given the Society and the Conference at which they are presented.

3. The Society shall not grant previous or simultaneous publishing rights to any of the papers it intends to publish.

4. The Society shall not be responsible for statements or opinions advanced in publications, reports, papers or in discussion at its meetings unless specifically approved by Council.

5. An abstract not to exceed one-third the original of any paper presented at a Conference may be published without further permission from the Society provided accompanying credit is given to the Society of Plastics Engineers and the specific Conference.

PLANNING - KEYSTONE TO MATERIAL CONVEYING SUCCESS

Robert J. Munns

Whitlock, Inc.

Farmington, Mich.

INTRODUCTION

One of the biggest challenges facing fast growing plastics processors today is the development of an efficient method to cope with increased material demands.

Processors risk being buried under their own inventories, and they face increased labor costs, wasted space, and hazardous working conditions unless steps are taken to incorporate their materials handling into their overall production operations.

The obvious solution is to turn this time-consuming effort over to an automated conveying system. Today, automated conveying systems are so varied that even the small processing plants can realize significant savings with the right type of installation and equipment for their size. For the medium and larger plants, the automation of materials handling is vital to the operating efficiency of the plant. Smaller plants, then, should automate. Larger plants <u>must</u>!

But, the success of such a system hinges on the care taken in pre-planning - long before the equipment selected is installed and started up.

From the equipment suppliers' standpoint, distinctions based on plant size are only provisional. The dramatic growth that has characterized the plastics industry quickly changes the well-managed small plant into a medium size and then a larger facility. As a result, the smallest materials handling system must either have a built-in provision for expansion, or be adaptable to integration into a larger system.

It is important in the beginning stages of materials handling automation to start with the simplest system possible to do the job needed, but to make sure the basic design is flexible enough to expand with the increased processing activitvp of the plant. Predicting this increase is a difficult task for both the processor and the equipment supplier, but is a necessary one if the groundwork is to be laid properly.

This "open-end" type of system will pay large dividends in the future, by quickly paying for itself today - yet not becoming obsolete tomorrow.

BASIC SYSTEM REQUIREMENTS

The first step in planning, irrespective of plant size, involves analyzing

the processor's operation. The choice of materials handling equipment must take account of three basic factors:

1. Material shape, size, bulk density and flow characteristics.
2. Production requirements, such as pounds per hour needed at each location, distance from storage container to press, number of different materials to be conveyed, etc.
3. Method of material receipt and storage.

Generally, the method of material receipt and storage is a major factor in designing materials handling systems. Smaller plants, which use limited quantities of plastics, purchase raw materials in small containers and move them manually to processing machine stations. The beginning of automated materials handling involves moving the material from beside the machine into the machine hopper.

As volume increases, the reach of automation is extended so the material is brought by conveyor from storage to batch weighing stations, blenders, sampling stations, intermediate in-plant storage, or directly to processing hoppers as production demands. Ultimately, when production volume justifies the economical purchase of plastics in bulk, automation can be extended still further - right out to a railcar from which the material can be carried, either to a storage silo or directly to processing. Bulk trucks, which are usually self-unloading, will also usually dictate additional storage silos because of their limited shipping quantities. It is from the storage silos that the conveying system then picks up material and transfers it to the plant, as demanded.

It is knowledge of these refinements, based on experience, which can be of great help in making every dollar invested in such a system give full value in realized cost savings.

ANALYSIS

Properly surveyed, the information needed for the best approach to solving a specific plant's conveying problems will be recorded on a specification planning sheet, which includes more than just material types and conveying distances. This analysis will show the form, shape, moisture content, bulk density, seive analysis (in the case of powders) and the amounts of regrind used in the plant as well. Information concerning construction details, electrical specifications, storage silo details (if they are included), and miscellaneous information on soil tests, foundations, obstructions to tubing runs or equipment installation, equipment locations, power sources and material receipt methods will all be carefully set down before a recommendation is made.

Any short-cuts to this procedure can only breed misunderstandings and incomplete planning for the new system, and can affect the system's growth in the future, as well as its performance initially.

THE PROCESSOR'S PROOF

During this analytical stage, by the people who will be quoting the equipment, the processor can be gathering information which will help him in making a sound final decision.

If he sets up a balance sheet, similar to Figure 3, he can estimate, quite closely, his approximate cost per pound of material handled with the manual or

present methods, as opposed to the bulk receipt and automatic conveying methods which he is contemplating. He can get a dollar-and-cents proof of the savings which he will gain based on his particular plant's operation and the system proposed to help him do the job better.

For example, he can balance the following major items.

1. Price of raw materials, including freight received in containers against - price of raw materials received in bulk railcar or bulk truck.

2. Cost of handling shipment of bags, drums or boxes into warehouse against - cost of handling bulk shipment to silo storage.

3. Cost of handling stored material from warehouse to machine hopper against - cost of handling material from silo storage to machine hoppers, including capital equipment to automatically move material into the plant and the cost of operating and maintenance of this system.

4. Cost of lost, wasted or short-shipped product against - automatic conveying and silo storage which prevents lost, wasted or short-shipped products (when properly designed).

5. Cost of new construction for storage or additional production area as company grows against - cost of silo storage which will free warehouse for production use and eliminate new warehouse need.

Once he has broken these costs down into a cents-per-pound figure, the processor can quite easily weigh the investment being asked of him, against the savings, and he can well determine the approximate payout time for the investment.

Studies show that overall savings of bulk buying and automatic conveying can run from 2.5 cents to 5 cents per pound of product purchased, sometimes much higher.

BUILDING BLOCKS

Probably the best approach to analyzing the requirements of materials handling systems for various types of plants is to take the "building-block" approach - that is, an approach that adds units of air conveying equipment as production requirements increase.

Although no one type of materials handling system can be considered the best for all plants, air conveying methods are, by and large, the most popular, and are the ones we will deal with here. There are three types of air systems in general use:

1. Pressure (sometimes called pneumatic, and available in either small or large sizes).
2. Vacuum.
3. Vacuum/pressure.

All of these systems are pneumatic, or air conveying systems, and each is suitable for a certain range of conveying applications.

PRESSURE SYSTEMS

Simple, inexpensive venturi conveyors can be used by very small plants, as well as in captive shops of a smaller size, where clean compressed air is available in good supply. They are low in cost, but limited in the conveying jobs they can do.

The pneumatic venturi creates a slight vacuum which starts the material flow and then the air pressure pushes it.

A very simple pneumatic conveyor installation, where the unit is used to load a machine hopper from a beside-the-press material container is shown in Figure 5. The hourly capacities of units of this type range from a few hundred pounds to over 2,000 lbs., and material can be carried over distances up to 150 ft. Such conveyors can economically handle any free-flowing pelletized material with little difficulty.

The larger pressure systems (Figure 6) are generally applied when material must be delivered to a number of widely separated receivers located a considerable distance from the source of supply, and when the pressure drop of the conveying system is greater than the inches of mercury that is the normal operating pressure - and the limiting pressure - for most vacuum systems. This 10-12 inches of mercury is actually a vacuum, or negative pressure, and we mean here that when the negative pressure necessary to overcome the conveying line "drag" is greater than the available negative pressure of a vacuum system, we go to pure pressure systems. Materials are fed by gravity, into the airstream, through an air lock, and then blown to their destination.

VACUUM SYSTEMS

The vacuum systems (Figure 7) are generally used for conveying of free-flowing materials, either pelletized or powdered, at rates up to 15,000 lbs. per hour. They direct materials to one or several use points at distances up to 1000 ft. away from the source of material. These systems are highly efficient in power usage and require a vacuum receiver at each distribution point.

A typical system consists of a power unit, incorporating a motor and positive displacement blower, a vacuum hopper or receiver that is placed over the discharge area, conveyor tubing between the source of material and the vacuum receiver, and vacuum tubing between the vacuum side of the blower and the vacuum hopper.

The vacuum systems, by and large, are the most popular for handling plastics materials. This is because they are cool in operation and add no heat to the conveying lines as they move the material along. Heated air, caused by compression in the blower, is present only on the exhaust side of the blower.

Vacuum systems can be used for bulk railcar unloading, transfer of silo-stored materials into the plant, for proportioning regrinds with virgin materials, or refined into a multiple system that allows the feeding of several stations using only one vacuum power unit, as shown in Figure 4.

VACUUM/PRESSURE SYSTEMS

Vacuum/pressure systems, Figure 8, are generally used where material must be picked up at each of several sources of supply, or from bulk shipment vehicles

(e.g., railcars) which are not self-unloading, and delivered to one or several locations over long distances at capacities greater than 15,000 lbs. per hour.

As the name implies, the material is induced by vacuum into the system and into an intermediate receiver. At this point, the material is separated from the airstream. This intermediate receiver requires an airlock, which drops the material into the conveying line of the straight pressure portion of the system. This airlock also acts as a barrier between the negative pressure of the receiver and the positive pressure of the conveying line.

MORE BUILDING BLOCKS

Because of the variety of jobs which a properly designed system can do, be it a pressure, vacuum, or vacuum/pressure type, careful planning is necessary to realize the optimum return from the investment.

For example, additional system building blocks can be introduced if color mixing with concentrates or dry color pigments are done in the plant (color mixing can be economical even for medium and smaller size plants).

Metering conveyors and mixing blenders (Figure 9) are available, which will automatically mix and convey accurate amounts of color concentrates with natural materials; or dry pigments may be added to virgin pellets and dropped directly into the machine hopper. In fact, the automatic in-plant coloring operation is one sure way that a processor, using a variety of colors of one type of material, can gain bulk buying price advantages. By purchasing large shipments of natural virgin material he can accurately color his own material as he needs it. This eliminates unusable colors in his inventory and lowers his costs considerably.

Vacuum conveyors can also be modified to handle very fine particle materials, such as powders and dusty regrinds. These materials preclude the use of the pressure type of system unless expensive filtering, or material and air separating equipment is used. It is here where the vacuum conveyor really comes into its own.

This powder handling can be done in two ways. First, with a cyclone separator attachment (Figure 10) mounted on top of a vacuum hopper to separate particles from the conveying air; and secondly, by a special extended filter (Figure 11) which allows handling of very fine powders, such as phenolics and other thermosets or dusty thermoplastics.

This latter development in vacuum conveying - the filter extension - promises to be of importance to processors needing to convey powders which contain so many fines they would probably clog the normal vacuum conveyor filter, or carry over seriously into the filtering areas of a cyclone system.

AUTOMATION AND BULK BUYING

Full automation involves purchasing plastics materials in bulk - by the truckload or railcar load - and using automatic methods for moving it into silos or directly to processing operations.

For the larger plant, the price incentive for purchasing materials in bulk is a substantial factor when considering the installation of a completely automated bulk storage and materials handling system. Added to the favorable price differential are reduced labor costs, reduced plant storage space requirements,

increased speed in handling, increased cleanliness, and increased efficiency.

Documented cases are on record of complete repayment of an investment in full automation in from one to three years, depending upon the type of system and the volume of material purchased in bulk.

A fully automated system provides four basic functions:

1. Automatic unloading of bulk transport vehicles.
2. Silo storage of bulk plastics, either pellets or powders.
3. Automatic distribution of material into and within the plant.
4. Inclusion of color blending, regrind proportioning, and other supernumerary operations, into the total automated system.

The relevance of pre-planning to plant design is particularly apparent in the case of these large bulk handling systems. Using bulk silos erected outside the plant, rather than interior warehouse space, can reduce construction costs substantially. For example, 475 sq.ft. of warehouse space would be required to hold 100,000 lbs. of boxed or bagged material, or pellets. Assuming construction costs at a minimum of $10.00 per sq.ft., this interior storage area would cost $4,750.00. The same sum would purchase a silo with the same capacity, or provide better than half the cost of that silo installation. Considering the money saved by eliminating the labor needed to handle this quantity in bags, and the contamination-free features of silo storage, the relative economy of the silo is evident.

From the silos, of course, the material can be conveyed to any number of intermediate in-plant locations or directly to processing. At each stage of material transfer, there is an opportunity for the processor to save time, material, manpower and money.

A vital part of the new "total systems" concept is the installation of such storage and conveying systems by a properly trained and competent contracting company. This is the final stage of the program and all the planning which has led to the installation can be rendered useless if the equipment is not properly installed and balanced during the start-up procedures.

The planning, engineering, component design, and the installation, must work together for a successful operation. Properly handled, such a program can bring the processor a bonanza of extra profits and he can successfully meet the challenge of his rapid growth.

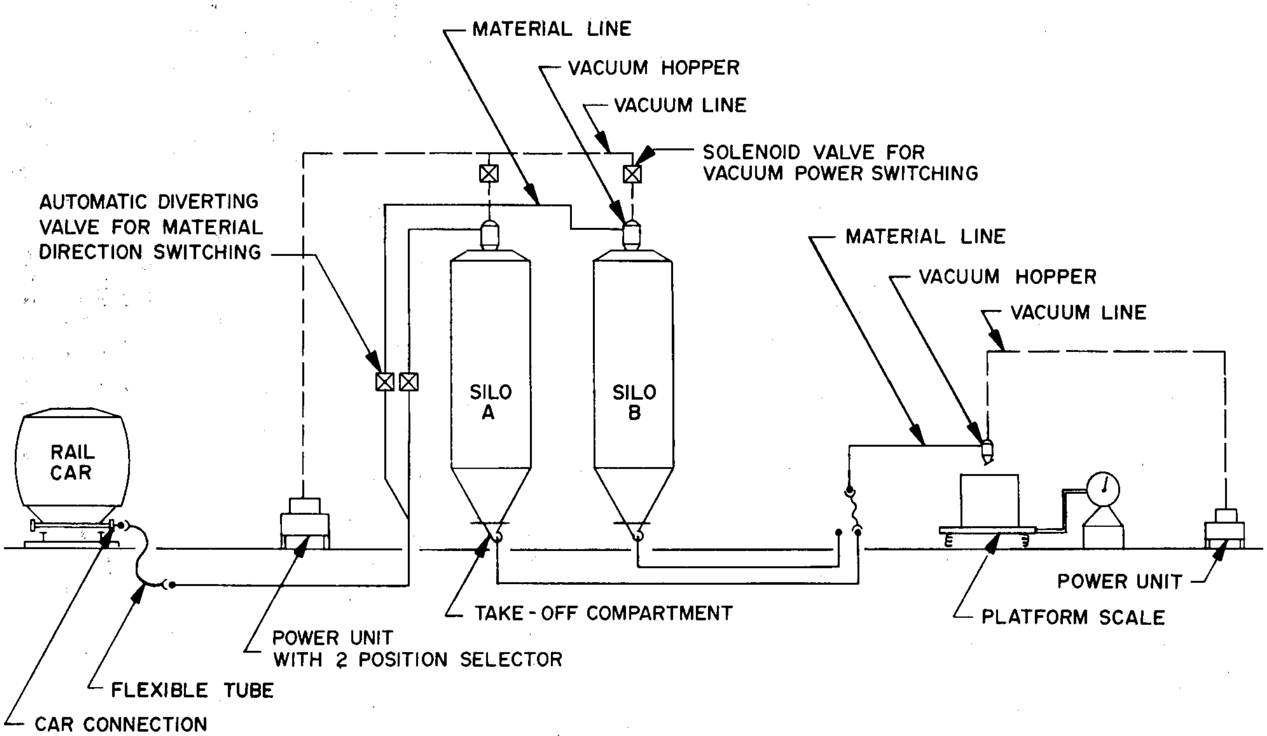

FIGURE 1 **Automated conveying systems are so varied that even the small processing plants can realize significant savings through proper planning and selection.**

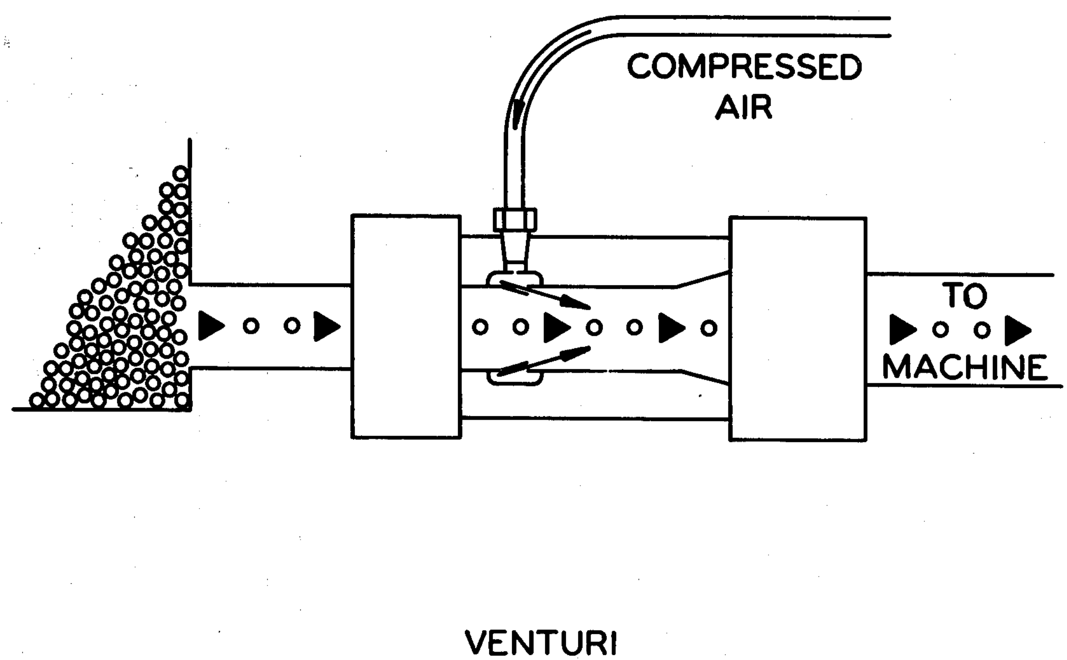

FIGURE 4 **Compressed air, entering the venturi of small pneumatic conveyors, creates a slight vacuum which starts pellets moving. Once past the air linet, materials are pushed to processing in tubes.**

WHITLOCK, INC.

23231 INDUSTRIAL PARK DRIVE • FARMINGTON, MICHIGAN 48029
AREA CODE 313-477-7100 TELEX NO. WHIT FARM 22-2452

SYSTEM SPECIFICATION SHEET

(Enter one system per form)

PRESSURE AND VACUUM PRESSURE SYSTEMS

☐ Per customer order # ________ Per quote File No. ________
☐ For System to be quoted Date ________
☐ For Turnkey System No. ________ Page ____ of ____ Pages

Customer Name ________ Phone No. ________
Address ________ Contact Name ________
City ________ Quote to ________
Instruction Manuals to be sent to: ________

Product to be conveyed: End Product: ________
Name ________ Bulk Density ________
Form and Shape ________ Sieve Analysis ________
Angle of Repose ________ Misc. ________
Moisture content ________
Temperature ________
Regrind used: Yes ☐ No ☐ Percentage? ________
Remarks: ________

CONVEYING DATA: Distance ________
Capacity required ________ Material Line ________
Future ________ Vertical ____ Horizontal ____ Bends ____
Vacuum Line ________
Vertical ____ Horizontal ____ Bends ____

Construction Details:
Electrical – Volts ____ HZ(Cycles) ____ Phase ____ TEFC ☐ JIC ☐ Exp. Prf. ☐ Customer Spec. ☐
Paint – Color: Standard ☐ Other ________
Material in contact with product – Steel (Oxydized) ☐ Aluminum ☐ Stainless ☐ Painted ☐ Epoxied ☐
Discharge – Vac. Hopper ☐ Type mounting – (Indicate on sketch)
Cyclone ☐ Roof vent ☐ Atmosphere vent ☐
Pick up – Vertical ☐ Horizontal ☐

STORAGE: Outside Plant ☐ No. ________ Inside Plant ☐ No. ________
Cone: 45° ☐ 60° ☐
Capacity: required each (indicate on sketch): Under Hopper (cone) Clearance: Std. 27" ☐ Other ☐ ________
Truck fill: Yes ☐ No ☐

Accessories: (Check req'd.)

Ventilator .... ☐	Deck Perimeter Guard Rail with toeboard .... ☐	Crosswalk Quantity ________ Length ________
Pressure vacuum valve .... ☐	Oversize door .... ☐	Louvers skirt Quantity ________
Manhole (in deck) .... ☐	Ladder with cage to grade .... ☐	Level Sensors
Split dome access above hopper .... ☐	8' above grade .... ☐	Hi ☐ Mid ☐ Lo ☐
Rack and pinion for slide control .... ☐	Dust collector with bag .... ☐	Metritape ☐

Miscellaneous Installation Information:
Unloading: Customer ☐ Whitlock ☐
Labor: Non Union ☐ Union ☐
Foundation: Customer ☐ Whitlock ☐
If by us: A. Soil Test Customer ☐ Whitlock ☐
B. Plot Plan ________
C. Location Sketch include with sheet ☐
D. Reference to building foundation ________
E. Accessibility of site ________
F. Ground conditions ________
G. Removal of dirt from excavation Customer ☐ Whitlock ☐

Tank Paint – Specify ________
Epoxy Lined – Specify ________

Storage Installation:
A. Room available around foundation for trucks and cranes ________
B. Type of pavement or ground around foundation ________
C. Obstructions overhead Yes ☐ Specify ☐
D. Gates or doors Width ☐ Height ☐

Conveying equipment:
A. Location of power units (sketch) ________
B. Pipe installation (sketch on reproduceable sheet) ________
C. Type of building – specify:
1. Roof ________
2. Walls ________
3. Ceiling Ht. ________ Type ________
4. Column Spacing ________

Electrical:
A. Power ________ Volts ________ HZ (Cycles) ________ Phase ________
B. Indicator panel location (Sketch) ________
C. Existing Light Panel Location (Sketch) ________
D. Existing Power Panel Location (Sketch) ________

Freight: Rail ☐ Truck ☐
Distance from Rail Siding to Tank pad ________
Tax exempt: Yes ☐ No ☐
Permits by: Customer ☐ Whitlock ☐

FIGURE 2 A typical System Specification Planning Sheet includes a host of information . . . all of it necessary for careful analyzing, prior to equipment selection and layout.

Prove It for Your Plant – Bulk Buying and Whitlock Automatic Conveying Pays!

PLASTICS MATERIAL HANDLING BALANCE SHEET

COST PER POUND

Price of raw materials, including freight, received in containers
Amount of material received, per shipment ________ lbs. = ______ ¢/lb.

Cost of handling shipment of bags, drums or boxes into warehouse:

	Man Hours	Ave. Wage (include all fringe benefits and overhead factors)
Unload from vehicle to dock to warehouse.	______	______
Stack in warehouse.	______	______
Fork truck cost (include fuel and maint.).	______	______
Total	______	______

______ Total Man Hours
X ______ Average all wages/hr.
Cost per pound: = ______ ÷ pounds in shipment = ______ ¢/lb.

Cost of handling stored material from warehouse to machine hopper:

	Man Hours Worked	Ave. Wage (include all fringe benefits and overhead factors)
Unstack, move from warehouse and deposit in machine areas.	______	______
Separate from pallets, open container and/or dump into other container or machine hopper.	______	______
Remove empty containers and store, bundle or destroy.	______	______
Fork truck cost (include fuel and maint.).	______	______
Total	______	______

______ Total Man Hours
X ______ Average all wages/hr.
Cost per pound: = ______ ÷ pounds used per day or shift = ______ ¢/lb.

Cost of lost, wasted or short shipped product:

% And Lbs. of Annual Purchases

(a) Short weight – a small discrepancy in the weight of each container can amount to considerable total annual shortage. Annual Estimate ______ % = ______ lbs.
(b) Short count or receiving inventory errors. Annual Est. ______ % = ______ lbs.
(c) Damaged bags, drums or boxes (received or in handling) Annual Estimate ______ % = ______ lbs.
(d) Spilled and/or contaminated material due to damaged bags, weather, rodents, insects, material transfer within plant and manual hopper filling. (Can average 2% of total purchase) Annual Estimate ______ % = ______ lbs.
Totals ______ % = ______ lbs.
Est. Total lost, wasted etc. ______ lbs. X ______ c per pound = $ ______ ÷ Annual Material Purchase = ______ ¢/lb.

Cost of new construction for storage or production:

Area now used for stored material ______ sq. ft.
Cost to duplicate, or add, in new space for additional storage or for new production area
In plant $ ______ sq. ft. X ______ (Total sq. ft.) = ______ (New Space cost) ÷ ______
years (Book Life of building) = $ ______ (Annual Ave. Cost.)
Average annual cost of new construction $ ______ ÷ Annual material purchases = ______ ¢/lb.

In addition to the lost time in manual handling of materials into, and through the plant, must be considered the expenses of lost efficiency, fatigue, strain and accidents caused by spillage and falls. These are usually considered as a part of overhead expenses, thus raising true labor costs. Reducing them lower's overhead and adds profits to your operation.

TOTAL COST PER POUND WITH PRESENT OPERATION = ______ ¢/lb. (A)

______ ¢/lb. **Price of raw materials received in bulk railcar.**

______ ¢/lb. **Price of raw materials received in bulk truck.** Amount received per shipment ______ lbs. per railcar
______ lbs. per truck

Cost of handling bulk shipment to silo storage:

(a) ______ ¢/lb. (a) Via bulk truck: Driver connects self-unloading truck pump to silo filling line. Shipping clerk handles bills and may check for complete unloading.
(b) Via bulk railcar: One man can connect conveying system to car, operate unit and change connection to various compartments. Time to unload will depend on system capacity choosen. (Note: Only part of mans time is needed.)

	Man Hours	Ave. Wage (include all fringe benefits and overhead factors)
(b)	______	______
(b)	______	______
Total	______	______

______ Total Man Hours
X ______ Average all wages/hr.
(b) ______ ¢/lb. Cost per pound: = ______ ÷ pounds conveyed

Cost of handling material from silo storage to machine hoppers:

	Man Hours per day or shift	Ave. Wage (include all fringe benefits and overhead factors)
Man or men responsible for conveying system operation, material direction switching and/or maintenance	______	______
Total	______	

______ Total man hours
X ______ Average all wages/hr
______ ÷ pounds conveyed per day or shift = ______ ¢/lb.

Cost of capital equipment to automatically unload and/or move material to storage and/or the machine hoppers.

Equipment Quoted:	Price		Book Life	Annual Cost
Unloading	______	÷	______	$ ______
In-Plant Systems	______	÷	______	$ ______
Misc. Equipment	______	÷	______	$ ______

Total ÷ Annual Material use Total $ ______ ÷ Annual Material use = ______ ¢/pd.

Cost of Maintenance and Operating expenses of capital equip.

Determined by kw/hr. cost of plant for operating amp requirements of equipment choosen. Blower lubrication, filter cleaning or replacement are only regular items serviced and take only a few minutes. Once installed and adjusted, the conveying systems operate continuously with a minimum of attention and expense.
kw/hr cost: ______ ÷ pds. per hr. conveyed ______ = ______ ¢/lb.

______ ¢/lb. (from right column) Total (enter left) ______ ¢/lb.

Cost of lost, wasted or short shipped product:

______ ¢/lb. An automatic conveying system prevents spillage, breakage, etc. and the bulk shipping vehicles are accurately weighed full and empty to assure nearly complete material transfer to storage. The percentage per shipment which might be lost is minimal and will not affect total per pound cost. Bulk storage eliminates guess work of inventory with proper level sensing control devices.

Cost of storage facilities which will free warehouse for production use.

Capacity of storage silos planned – ______ lbs. ea.
Number of silos ______ X Uninstalled price $ ______ /ea = $ ______
Add Total Installation cost, pads, erection etc. $ ______
Total $ ______
Total ÷ No. of silos = $ ______ (Ave. cost per silo)
Total average cost per silo ______ ÷ ______ yrs. book life of silos = $ ______ (Ave. annual cost per silo)

______ ¢/lb. = Ave. annual cost of all silos $ ______ ÷ Total annual purchases.

— OR —

If bulk purchases are not possible, the warehouse can be re-organized for central conveying to the machine areas, eliminating handling bags, drums or boxes to the machine room floor and effecting large savings in manpower, time and material:

Cost to reorganize warehouse for central distribution @ $ ______ sq. ft.
X ______ (Total sq. ft.) = $ ______ (Storage space cost) ÷ ______
years (Book Life of building) = $ ______ Annual Ave. cost.
______ ¢/lb. = Average annual cost of container storage space $ ______ ÷ annual material purchases.

______ ¢/lb. (B) TOTAL COST PER POUND PURCHASED AND MOVED AUTOMATICALLY.

______ ¢/lb. TOTAL SAVINGS PER POUND OVER PRESENT HANDLING METHODS. (A minus B)

SAVINGS FROM ALL PHASES OF BULK BUYING AND AUTOMATIC CONVEYING CAN RUN FROM 2.5 TO 5 CENTS PER POUND OF PRODUCT PURCHASED, SOMETIMES MUCH HIGHER!
Bulk Storage and Automatic Conveying fits in with continuous production because it eliminates the delays found in manual handling as well as the extra expenses.

Prove It for Your Plant – Bulk Buying and Whitlock Automatic Conveying Pays!

FIGURE 3 This kind of "Balance Sheet" lets the processor put a cents per pound cost measure on his present handling methods so he can closely predict the payout of the proposed automatic system.

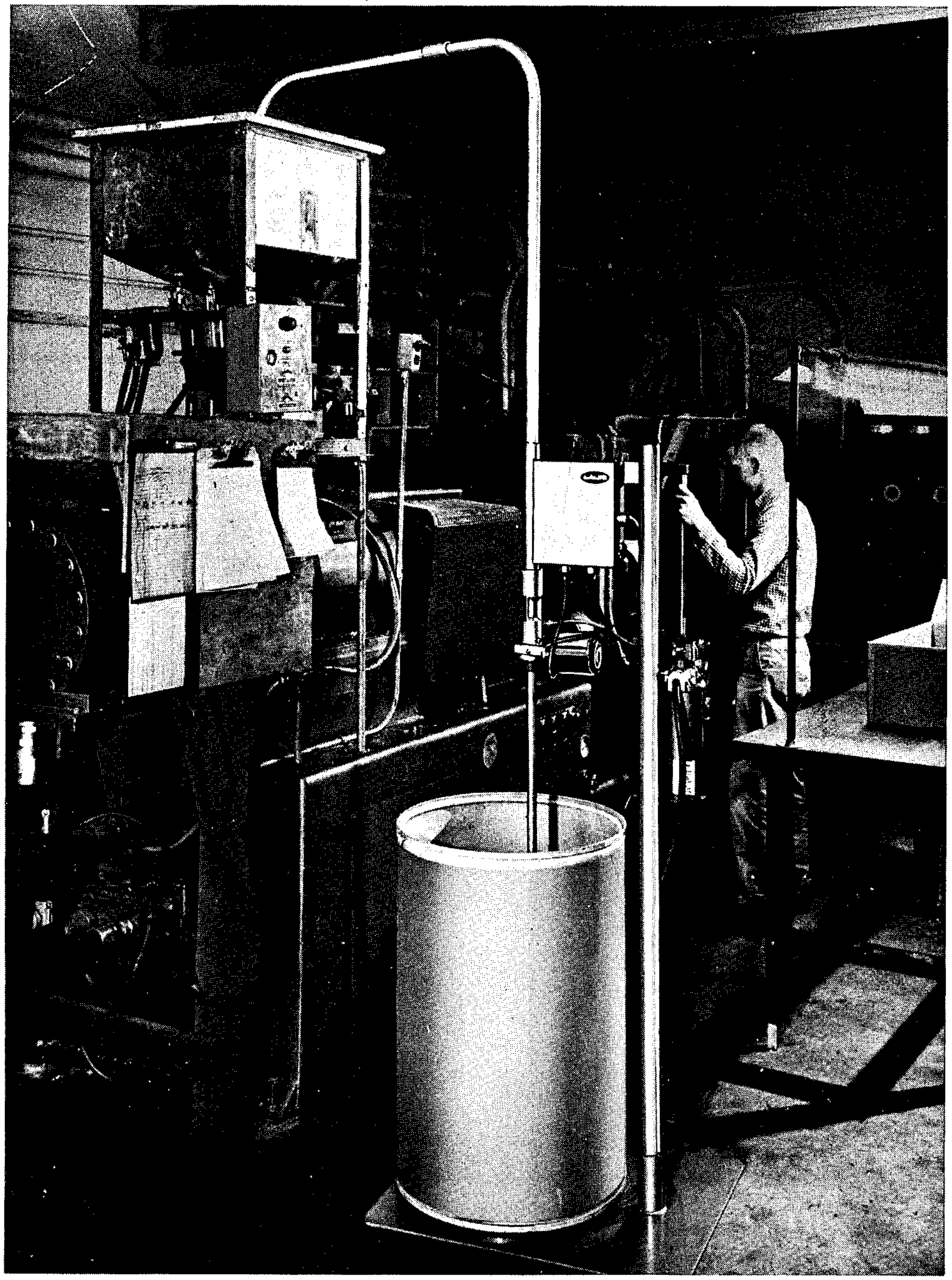

FIGURE 5 Simple pneumatic conveyors can be the beginning of materials handling automation.

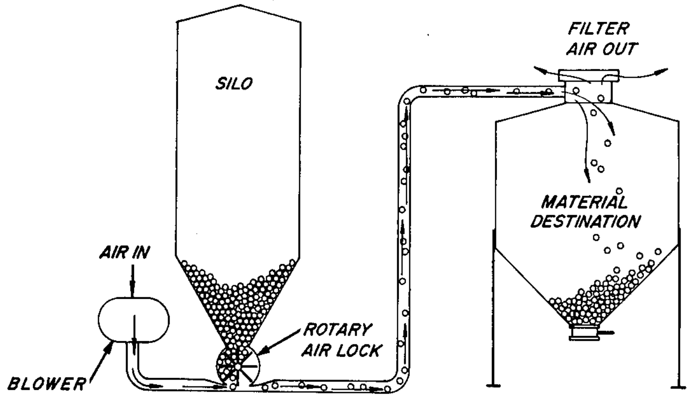

FIGURE 6 Large pressure-type conveying systems are applied when widely separated receiving points need large amounts of material and are a considerable distance from the source of supply.

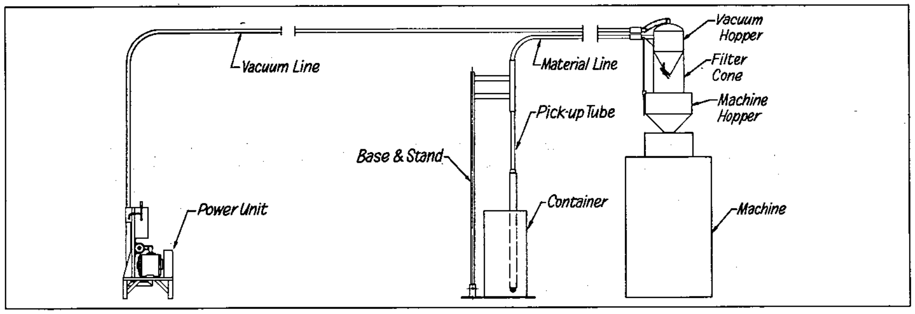

FIGURE 7 Vacuum systems can handle either free-flowing pellets or powders at rates up to 15,000 lbs./hr. They are highly efficient in their use of power and are contamination-proof.

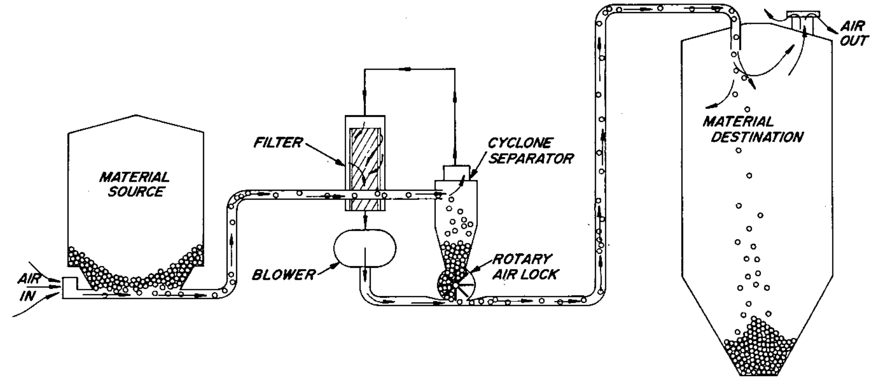

FIGURE 8 Vacuum/Pressure systems are used where several sources of supply must feed several locations over long distances and at large capacity rates.

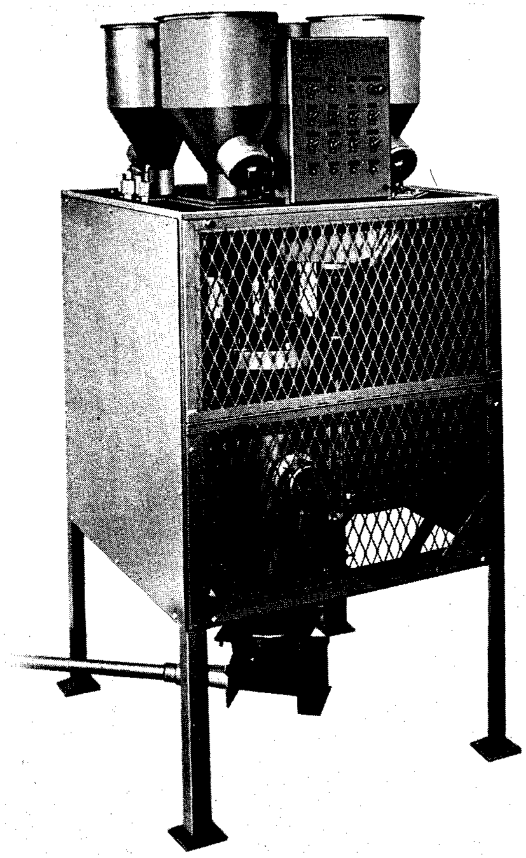

FIGURE 9 Automatic coloring blenders can allow processors to buy natural material in bulk quantities, coloring material as it is needed.

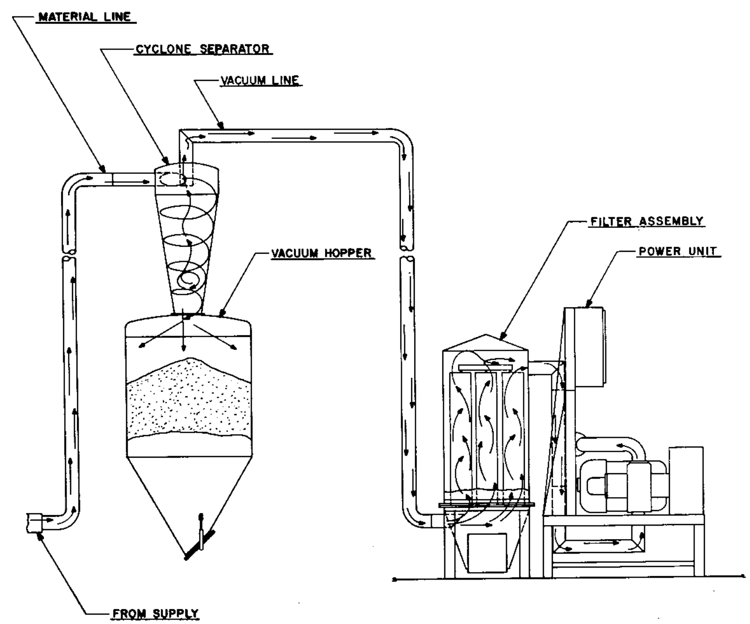

FIGURE 10 The cyclone separator, mounted on the vacuum hopper, separates fines and material from conveying air, allowing powder handling with a minimum of filter maintenance.

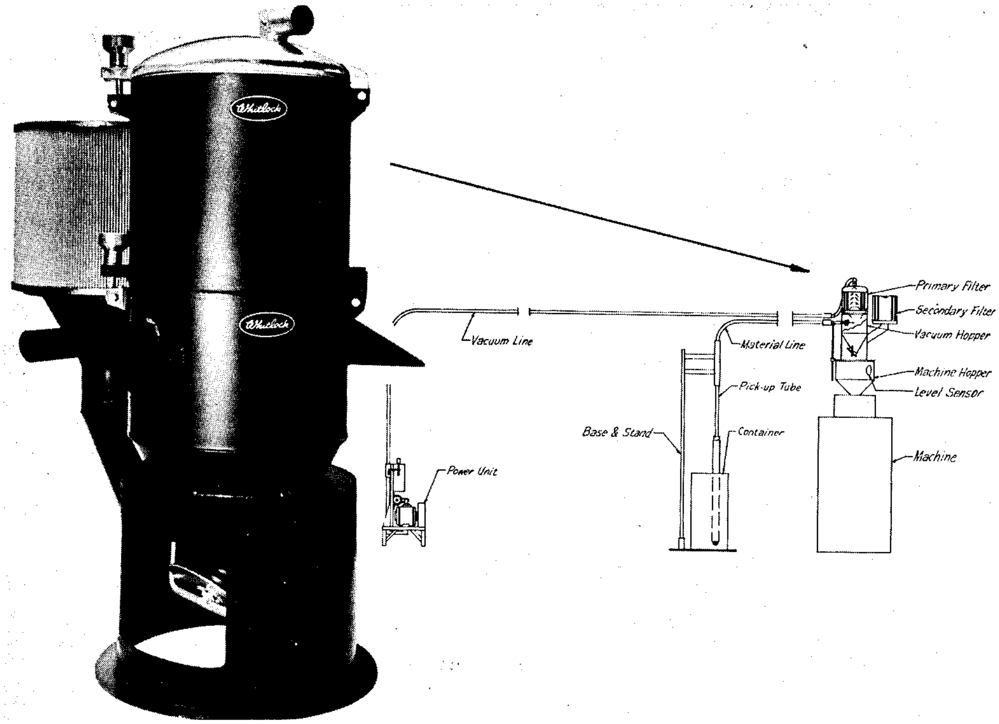

FIGURE 11 **The vacuum hopper Filter Extension permits the handling of extremely dusty materials, such as phenolics.**

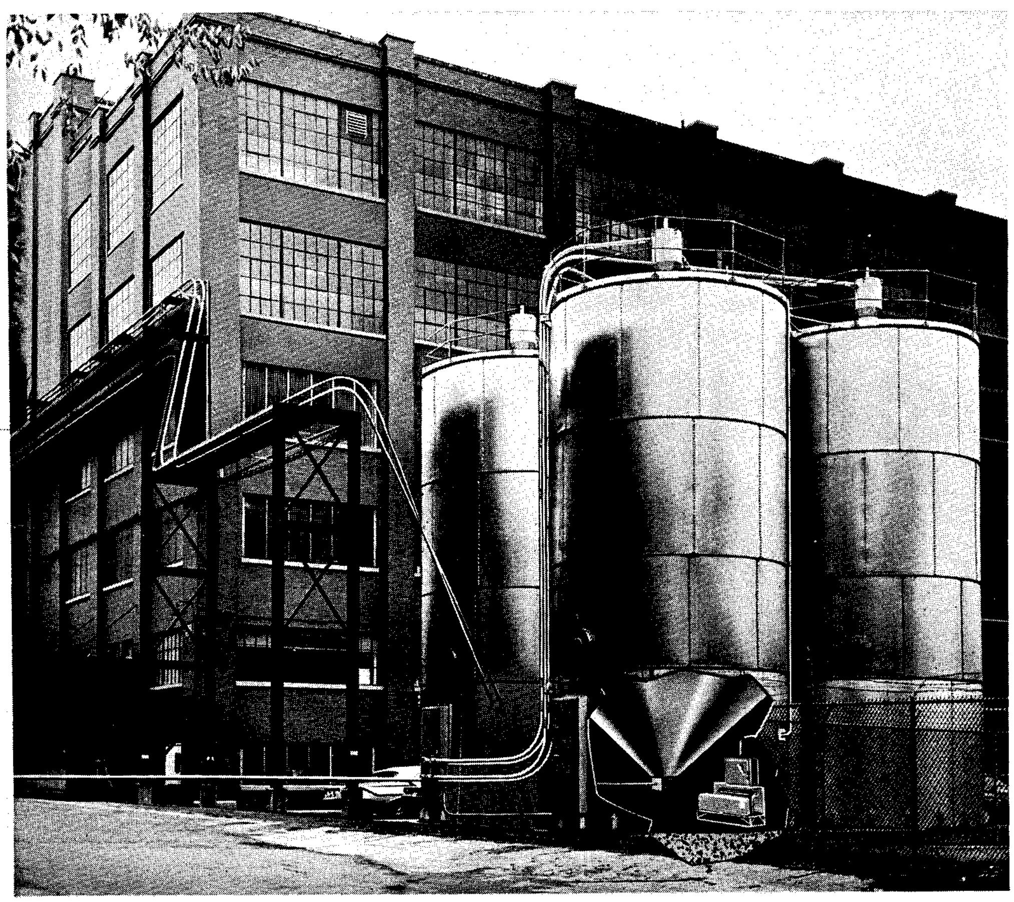

FIGURE 12 **Added to the favorable price advantages of bulk buying are reduced labor costs, reduced plant storage space requirements, and increased speed in handling and efficiency.**

AUTOMATING THE DRY COLORING PROCESS

John C. Reib

President

Conair, Inc.

Franklin, Pennsylvania

ABSTRACT

The drum tumbling operation is cumbersome and costly in itself; in addition, it precludes the installation and operation of total automatic materials conveying systems, because at some point between receiving and machine hopper, the material must be transferred, usually manually, to drums for tumbling.

Automatic, on-the-press loading and coloring machinery is now available to eliminate the need for drum tumbling. This paper discusses the operating cost factors involved in the conversion to automatic coloring.

The day of the universal colorant for plastics is coming. The universal colorant will be a substance that will provide any tint or shade of any hue, for any plastics material, at any processing temperature, without bleeding, crocking, or in any other manner affecting the quality of the finished product.

The trouble is that nobody can tell us when such a dream colorant will be available, or at what price; and in the meantime, we will continue to have problems with coloring, and the shocking waste of time, energy, equipment, and material which have been accepted as necessary evils in a coloring operation.

It is not the purpose of this presentation to eliminate, or even to define, the variables in the <u>chemistry</u> of colorants and plastics materials. This is the job of the chemist. Rather, we restrict ourselves in this paper to a consideration of the <u>mechanical</u> process of getting material and colorant to the right place, at the right time, in proper proportions, at the lowest cost.

Further, we will limit our discussion to <u>dry</u> color, as the most widely used and least expensive form of colorant; although the same basic principles explained here are also applicable to color concentrate and, within their limits, also to paste colors.

Plastics processors color their own materials for one reason - dollars. The processor who can afford to buy precolored materials, or whose color match specifications are so rigid that he does not want the responsibility of making the match, is the exception. Most processors daily face the chore of keeping coloring

costs lower than the premium they would have to pay for the same volume of pre-colored material.

The general term "coloring costs" is not as intangible as it sounds. It includes a number of measurable items:

1. colorant purchasing,
2. inventory of colorant,
3. man-hours in coloring room,
4. coloring room equipment,
5. coloring room space,
6. contamination and housekeeping,
7. spillage and other waste,
8. storage of batch surpluses, and
9. delivering material to machine hopper.

It ("coloring costs") also includes two less measurable, but possibly much greater, operating costs: (10) employee safety, and (11) employee morale. With the safety hazards and general mess associated with dry coloring, the only people who like the stuff are the purchasing agent and the supplier.

The purchasing agent and the supplier have a strong argument, though. They point out that items (1) and (2) above (base price and inventory investment) are far lower in cost than any other present method of supplying color for the end product.

Obviously, the way to eliminate items 3, 4, 5 and 6 is to eliminate the coloring room. Item 7 cannot be controlled in the same manner, because we can't eliminate people except by reducing the need for them; but we can limit spillage and waste if we don't give people the opportunity to handle material or measure (mismeasure?) colorant.

Surpluses of dry colored material will exist as long as the coloring room foreman tries to outguess the production foreman, or as long as it is just as easy to tumble 150 lbs. (which is what fits comfortably in the drum) as it is to tumble 105 lbs. (which is what the production order called for), or he loses count.

Delivering dry colored material to the machine hopper is a job for strong men and strong ladders. The most modern, efficient automatic vacuum, air, or mechanical loaders on the market today cannot convey dry colored material without separating the dry color from the material, undoing in seconds everything the drum tumbler worked so long to accomplish.

The solution to this whole lineup of variable costs seems to be to mount a drum tumbler on each machine hopper, on top of that a machine to measure material and dry color into the drum, and on top of that, a silo of material. Don't laugh! In effect, it's been done (Figure 1).

Viewed in terms of pounds of finished parts per hour that the great majority of plastics processing machines can produce, the problem takes on a new dimension. Rather than thinking in terms of 500 to 1,000 lbs. per batch on a tumbler, let's consider the processing machine's use: 150 lbs. per hour is a good average use figure. Per machine, then, we need a miniature drum tumbler capable of blending and dropping directly into the machine hopper about 150 lbs. of dry color coated material in one hour. That's just 7-1/2 lbs. each three minutes.

Since we can't have our miniature, 7-1/2 lb. capacity, tumbler flopping around on the hopper, let's bolt the drum in one position and get our mixing action by inserting into the drum an agitator paddle that will stir the material and dry color sufficiently to coat each pellet within our three-minute time limit.

How do we get the material and dry color into the miniature drum tumbler? The material is easy: any automatic loader (Figure 2) can pull 7-1/2 lbs. in far less than three minutes, and some of the more powerful units available today can pull from storage areas hundreds of feet away from the production floor. The dry color is not so simply handled, however. There are more dry color formulas than there are plastics materials, and the range of bulk densities and flow characteristics among dry colors is the range from talcum powder to sand. Air or vacuum conveying is out of the question because of containment and filtering limits, unless you are satisfied to have color all over your plant or an impossible filter replacement schedule. In addition, the dry color must not only be conveyed but must also be metered into the miniature tumbler in precisely designated amounts. It all adds up to a mechanical feeding device drawing from a supply of dry color. The container for the dry color supply (Figure 3) can also be comparatively small, because normally a 7-1/2 lb. material charge can be colored by a few grams of dry color.

Two things remain to be done: seal and control. We must seal off each compartment from the others so that tumbler, loader and color supply can operate independently, in the proper sequence, and each for the amount of time necessary to do its particular job. In addition, the seal is necessary because most dry color pigments are easily airborne.

To control the series of steps in our miniature tumbling room (i.e., load material, meter in dry color, blend the two, and drop the coated material into the machine hopper) is a comparatively uncomplicated matter in this day of automation.

This whole idea of a sealed coloring room on the hopper was submitted in prototype form to a number of processors over three years ago, and we soon found that the distance between idea and marketable product is very great, and the variety of processing needs very wide. Many research and development hours have been devoted to producing a range of models to match a range of needs.

For example, the fantastic range of pigments, fillers, extenders, wetting agents, bonding agents, and other additives that can only be named by the color suppliers, make it possible for a good supplier to compound almost any color for use with almost any material under almost any conditions. However, that same facility becomes a major consideration in the design of the feed mechanism, because a device which meters one color compound freely and precisely can stall under the weight or consistency of a different compound of the same color. Most color suppliers, until the last two or three years, compounded their dry color pigments with materials, of unpronouncable names and obscure origins, specifically to make the colorant less dusty and make it adhere to the plastics pellet through the 15 to 30-minute drum tumbling torture, because that's what the processor needed. The same adhesive qualities, however, produce a nightmare of inaccuracy in a mechanical feeding device, because the colorant clings to the container, to the feed tube, to the measuring tool, and even to itself in clumps that make for wildly inaccurate metering.

The same compounding abilities, of course, mean that the supplier can also adapt his colorant to the smooth, free-flowing consistency so necessary to automatic measuring, without affecting the quality of the color in the finished product. Since the equipment is sealed, he now need not be concerned about the so-called

"dustless" requirement.

There are other hazards to manufacturing miniature coloring rooms. How do you answer the processor who demands that his regrind also be conveyed, tumbled with and evenly distributed among the dry colored pellets, automatically? How do you accommodate the processor who wants automatic coloring on a high-speed extruder or blow molding machine which gobbles 500 to 600 lbs. of material each hour? What about the man with a color dispersion problem in one of his materials which can only be answered with color concentrate, and who insists that the same coloring unit automatically feed either dry color or color concentrate? (See Figure 4)

And don't think you can escape from the processor who tells you that he wants a long line of machines to be provided with any of several materials, and color, and regrind, and custom additives, all on one system, all centrally controlled, powered from one high-vacuum pump, but each capable of being operated individually.

Because such combinations of initially unique requirements, requests and demands, have been solved over the past three years, automatic on-the-press units and highly sophisticated systems have been developed and are now available as standard, almost stock, items.

Now that we have built a sealed tumbling room on top of the machine hopper, what have we accomplished in terms of reducing the "coloring costs" total? Let's review them one at a time.

1. <u>Colorant cost</u>

   We haven't changed this. But the purchasing agent is still happy, because he finds we're using less dry color for each job (see item 7 below); and the supplier is happy because we have made it so attractive to dry color that we are making more frequent use of dry color. Contradictory? Not at all. The arithmetic is simple: greater saving per production run means more dollars for more production runs.

2. <u>Inventory of colorant</u>

   This might have gone up or down, depending on the individual operation. Since we have made closer controls possible, dry color inventory will decrease if production remains stable or increases only slightly. On the other hand, the dollars saved leave room for substantial reinvestment, and the dry color inventory may very well increase to provide for increased coloring needs.

3. <u>Man-hours in coloring room</u>

   What coloring room?

4. <u>Coloring room equipment</u>

   What coloring room?

5. <u>Coloring room space</u>

   Same as 3 and 4 above; and at from $6 to $10 per sq. ft., this is

a major factor which is freed for more profitable uses.

6. Contamination and housekeeping

Cleaning hours and cleaning materials and equipment can be measured in dollars, but what about general plant and people cleanliness? Can you put a price tag on the elimination of the dry color dust clouds which settle on everything in sight?

7. Spillage and other waste

This factor ties in closely with item (1), base coat. Measuring the dry color is now a job done by a machine, and a machine can't think or guess. It can't think to add an extra scoop of color beyond what the formula calls for ("just to be safe" or "and one for the drum"), and it can't guess about how much to add or subtract for partially filled drums. Because the dry color is added just before the material enters the machine hopper, no provision has to be made to compensate for the amount of colorant lost to the air and to the bottom of the drum or bucket on the way from the coloring room to the machine hopper. Sloppy handling of bags or boxes of dry color is no longer a factor.

8. Storage of batch surpluses

Since our miniature coloring room only produces the amount of colored material actually needed for each run, the question of what to do with half-filled drums at the end of a run is removed from the manager's list of storage and handling problems.

9. Conveying dry colored material to the hopper

The conveying distance for the colored material is now a matter of inches in a sealed chamber. The highlift can get back to more productive work.

10. Employee safety

Improper lifting is still among the leading causes of industrial accidents. Next to a 100 per cent effective training course in safe lifting, the best way to eliminate such accidents (and the tremendous impact they have on insurance premiums) is to remove the necessity for lifting: like lifting drums of material on and off the tumbler, or lifting buckets awkwardly up a ladder, or wrestling large storage containers in the coloring room or in tight production aisles. Pellets on the floor make like uncontrolled roller skates. Material conveyed automatically, in pipes rather than in large containers, cannot be the cause of accidents.

11. Employee morale is as clearly a cost factor as any invoice. Cleanliness, order and limiting hard physical labor to a reasonable and necessary minimum all contribute significantly to the high morale which can be the difference between profit and loss.

While it is not strictly within the scope of this paper, it must be pointed out that the greatest benefit resulting from automatic dry coloring on the machine hopper is that it makes total automation of materials handling systems possible and profitable. Because there is no longer any reason to interrupt the flow of material from receiving to machine hopper, processors may now enjoy the additional savings realized from bulk purchasing and automatic in-plant conveying.

Can a cost saving tag, in dollars and cents, be assigned to each of the factors above? Certainly. Close cost control figures are kept by all processors as a matter of course - indeed, as a matter of survival - and a processor with adequate records can predict his savings. However, any general statement in terms of average dollars or even in terms of percentage of a given total would be misleading. Operating costs vary too widely by type of operation, volume of production, and geographic location for any all-inclusive statement except one: you will reduce your coloring costs per unit of production if you automate your dry coloring operation.

APPENDIX

HOW THE AUTOCOLOR$^{(R)}$ WORKS

Figure 5. When the level of material in the molding machine hopper falls, the sensing blade of the Autocolor swings down, closing a switch which starts the cycling control. The vacuum motor then draws uncolored material from the virgin material source to the chamber of the Autocolor until the chamber is full.

Figure 6. After the vacuum motor stops, a pneumatic valve opens, dropping the uncolored material into the mixing drum. At the same time, the color screw motor begins turning, feeding colorant to the mixing drum. As the colorant drops into the mixing drum, the color mixer motor rotates an agitator in the drum, churning uncolored material and colorant together.

Figure 7. As soon as the proper amount of colorant has been metered to the mixing drum, the color screw motor stops. However, mixing continues until the cycle is completed. The thorough mixing action of the Autocolor insures you of plastics material that is either well-coated with dry color or completely interspersed with color concentrate. During this time the filter between the vacuum motor and chamber is cleaned. A short burst of compressed air snaps the filter, dislodging any fines that might have accumulated during charging of the chamber. After the filter has been cleaned, the vacuum motor starts, and the chamber is recharged.

Figure 8. When mixing is completed, an air cylinder automatically opens a gate, allowing the material to drop into the molding machine hopper. If the sensing blade on the Autocolor is deflected by the new level in the molding machine hopper, the Autocolor will stop until more material is required. Otherwise, another color mixing cycle begins.

Figure 9. The Ratio Autocolor hopper loader is similar to the standard model except that it has a two-part vacuum chamber and two separate feed tubes. At the beginning of each cycle, virgin material is drawn into one part of the chamber. During this time, a Conair Line Valve on the regrind feed tube is closed. Closing the valve prevents air flow through the regrind side, assuring that the virgin material will be loaded even if the regrind source is empty. After the virgin material side of the chamber is full, the line valve opens and an adjustable charge of regrind material is drawn into the other side.

The amount of regrind metered during each loading cycle is controlled by setting the position of the regrind feed tube, which is adjustable and calibrated. When setting the ratio, moving the calibrated tube down into the chamber reduces the proportion of regrind material. After the ratio is set, the calibrated tube is locked in place with a thumb screw.

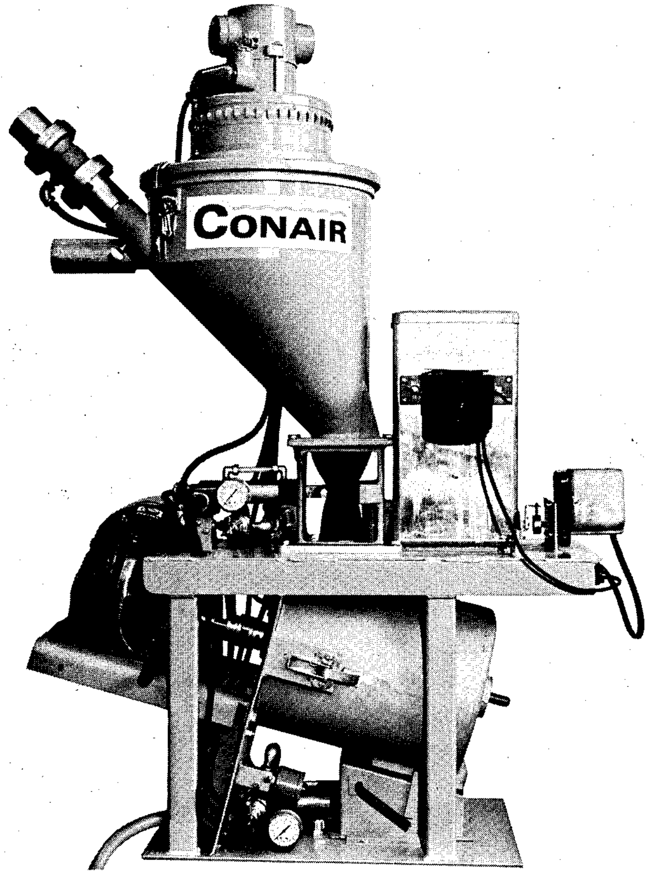

FIGURE 1

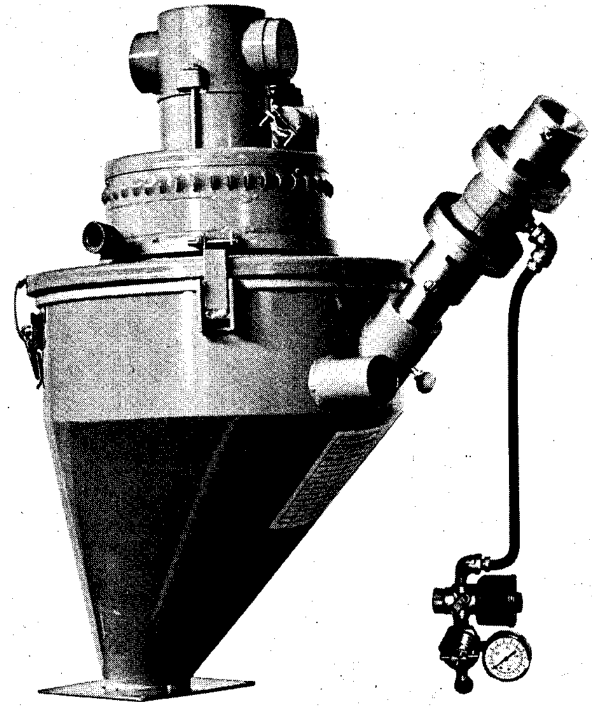
FIGURE 2

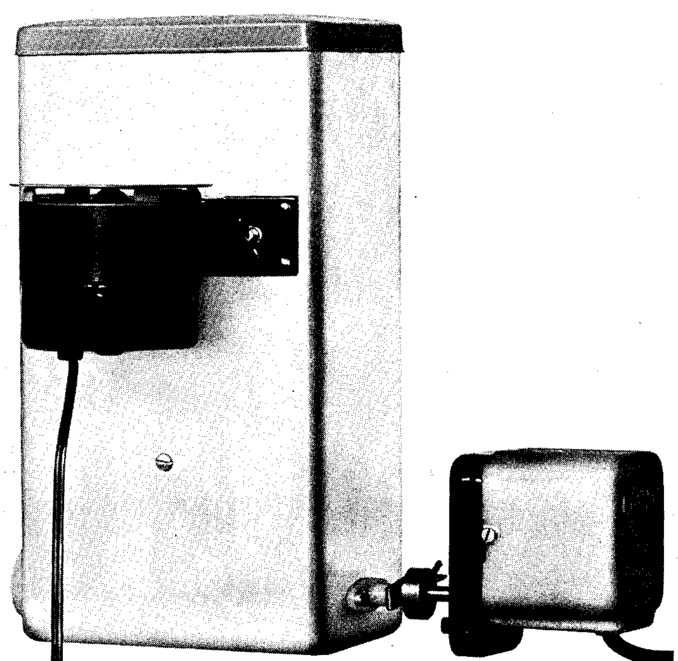
FIGURE 3

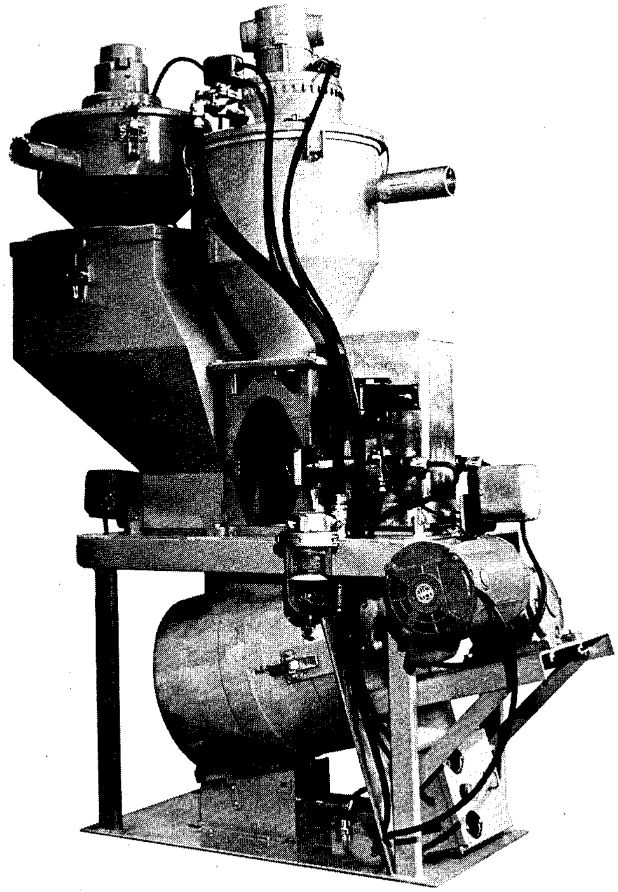

FIGURE 4

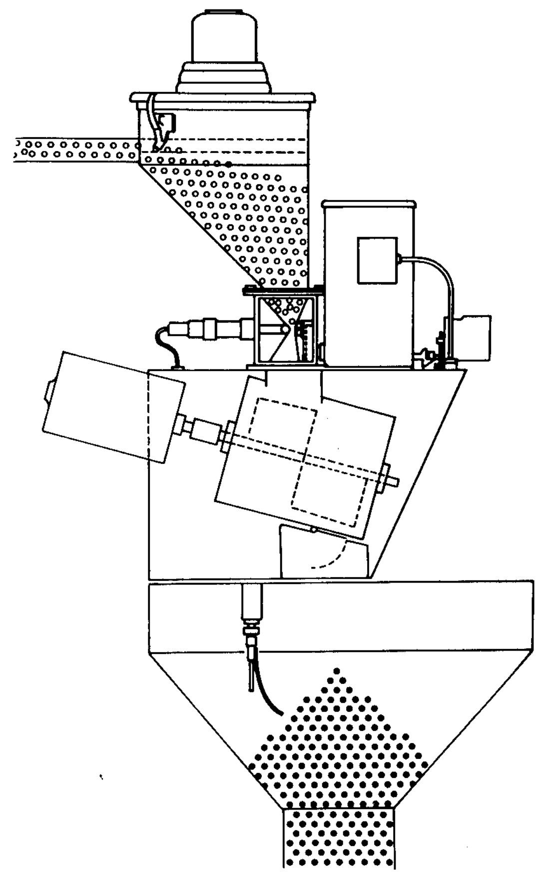

FIGURE 5

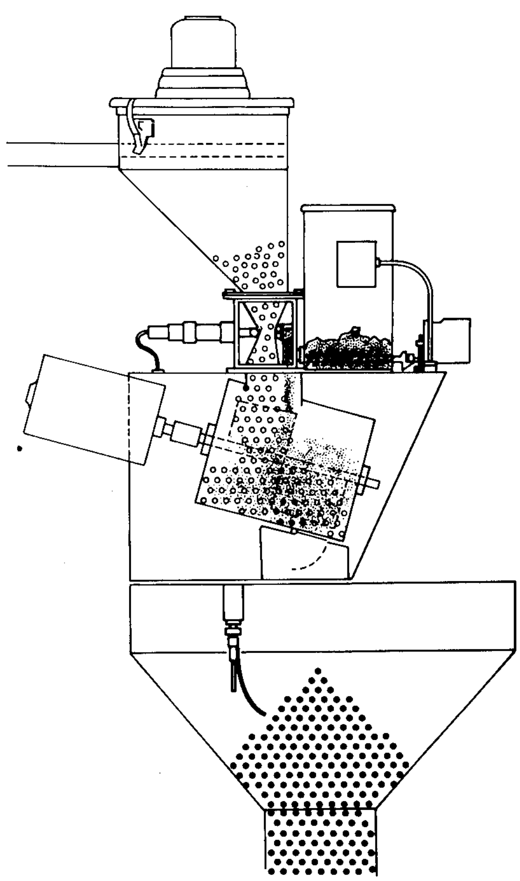

FIGURE 6

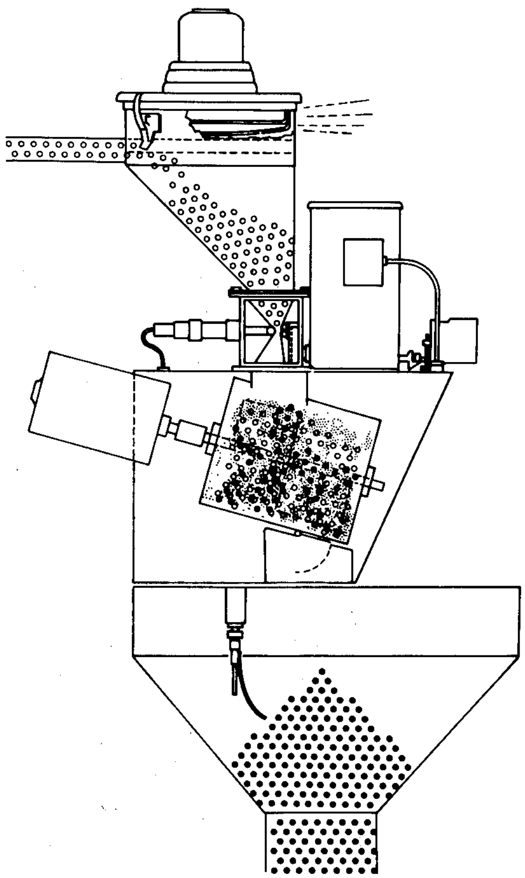

FIGURE 7

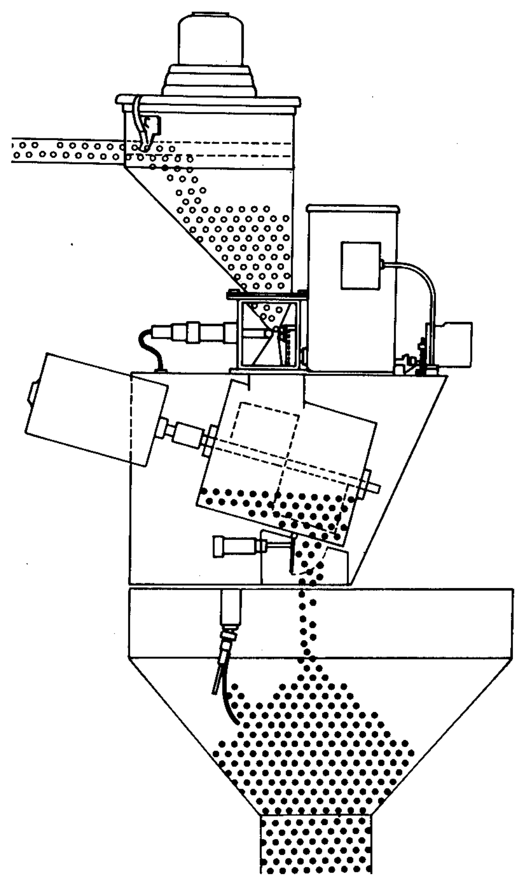

FIGURE 8

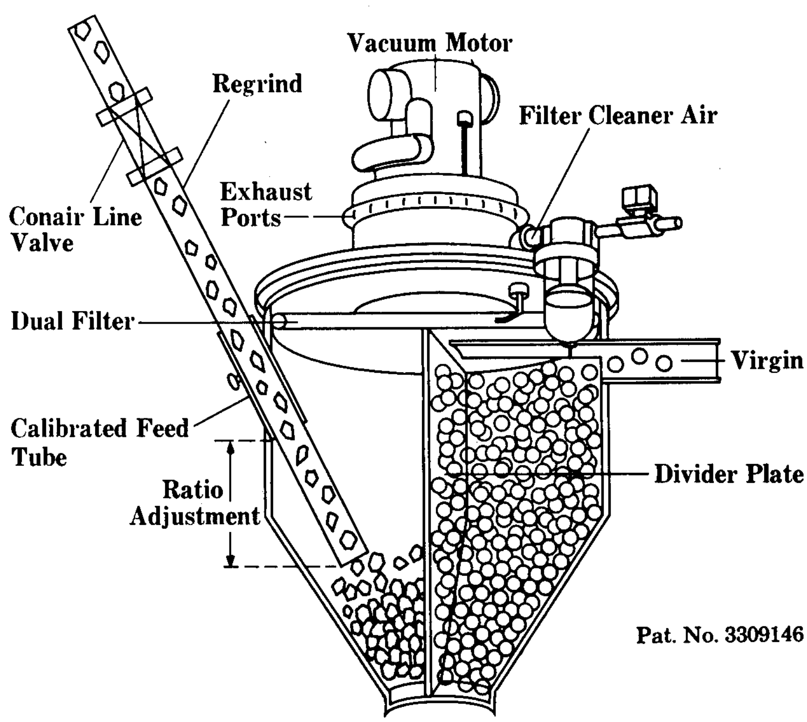

FIGURE 9

-02

COLOR CONCENTRATES FOR THERMOPLASTICS AND RELATED PROBLEMS

Myles Z. Schneider

Ampacet Corporation

Mount Vernon, N. Y.

INTRODUCTION

One of the major problems which has been a bane to the existence of the plastics industry has been color. In the present day of futuristic design and new product marketing concepts, it has been necessary for the fabricator to be able to bend with this new ideology and achieve an ability to change rapidly and cleanly as possible from color to color, and with as little difficulty as possible. This process should also be applicable to as many thermoplastics and methods of fabrication conceivable. Thus was developed the color concentrat - a material compatible with the thermoplastic being fabricated, having little or no effect on the physical properties, similar rheological characteristics, true color pellet to pellet and affecting very little the economic considerations of production.

For those not too familiar with what a color concentrate is, let me give you a short description. In order to facilitate your understanding, let us go through a common process of making a specific color concentrate for Y company.

Y company sends a red sample to the color concentrate manufacturer. He matches this red sample and finds for every 100 lbs. of resin he needs one pound of dry pigment to provide the desired shade. The concentrate manufacturer then takes this one pound of dry pigment and puts it with one, two or three pounds of a base resin and mixes it in a very high shear mixer and then provides this highly concentrated one, two, three or four pounds of a material in the same form as the fabricator uses when doing the processing. All that is required then is for the fabricator to put this highly concentrated color-plastics mix into a piece of low shear mixing equipment to melt and blend the color concentrate with the resin. This will then provide the processor with a completely uniform, thoroughly-colored finished product.

Now let us see why this product is being used and what are the major advantages of this method of coloring.

FLEXIBILITY OF INVENTORY

Instead of having to maintain an inventory on many different compounds, all that has to be maintained is a small inventory of color concentrate and the rest

in natural raw materials. This allows for a selection of any base raw material with whatever physical properties are required without the limiting factors created by a large inventory of each individual color.

ECONOMICS

This particular method is probably in dollar raw material value not cheaper than dry color on the face of it, and I will get back to this later, but is definitely much cheaper than pre-colored materials taken on the same basis of primary resin.

CLEANLINESS

The blending or mixing of color concentrates is as clean as blending natural pellets. It does not have the dusting and clean-down problems as associated with dry color.

QUALITY

Now, here is the area where color concentrate as a method of coloring shows its major advantage. I am not trying to say that color concentrate is the best method of providing the most uniform color. However, as a total concept of coloring a polymeric material, comparing all values, it provides the best method of securing a top quality fabricated product. There is an area of dialogue with respect to color concentrates, and oft' times a controversial one, which will actually demonstrate the reasoning for this little-known purpose of usage. This has to do with the change that all materials undergo on repeated heat history. In order to understand the concept discussed here, let us take the example of an injection molder using his scrap. He will take his base resin, let us call it natural ABC, and mold it; then regrind his trim, sprues and other scrap. This is then molded time after time. But let us see what happens when he uses this process. The material slowly changes in color, rheological properties, density and molecular characteristics. He could often see this occur in warpage of their sections. What does this have to do with color concentrates? Nothing in any major sense. However, as a comparison with a pre-colored material, everything. That pre-colored material also had to be made from ABC resin and had to be compounded under high shear and has taken the product along the step-down to degradation of the production. It is as if the molder had run that material through his machine and was starting with a straight reground material. Now, the argument can be brought forward that this still passes the basic raw material tests. Agreed! But at which end of the scale of the physical properties. The point that I am trying to make is that we have set up the natural resin ABC as the parameter of the requirements of our fabricated piece. We are not starting with the same "animal" as this item when we accept a fully compounded color. We already have one heat history built into this product. This rears its ugly head the higher we have to go in the fabrication temperatures of our various thermoplastic materials.

The answer to this problem is the use of color concentrates. Here we have a very small amount of the base resin present which has this one heat history. Generally not more than two to three per cent in molding and up to five per cent in thin-gauge extrusions. This enables the molder or extruder to select his raw materials from the listed properties provided by his supplier of resin and be 99 per cent sure that his colored product will perform equally as a natural material. By

the way, this also happens to be a fairly good reason for using dry color.

Speaking of dry color, we would like to bring back a point alluded to earlier. This is, that dry color, although cheaper in the long run, may be more expensive. This is especially so when coloring extruded shapes, blow molding bottles or thin-gauge sheets or films. We should all be aware that pigments as provided by dry color manufacturers and pigment suppliers have extremely large agglomerated particles. In order to break these down, both the dry color and pigment manufacturers take their products through a step called pulverizing. Theoretically, to get it down to its finest form, when used by the fabricator in his relatively low-shear equipment any material which has a free particle of pigment on the surface or included provides a point of weakness and poor physical properties. Especially with deep drawn formed sheets, high blow ups on bottles and quick draws on sheeting lines. It may not show up immediately, but can show up in rejected parts or scrap in production. By the way, one of the greatest votes of confidence provided for the use of color concentrates has been that a large per cent of dry-color manufacturers have gone into the manufacturing of color concentrates themselves.

This meeting has a lot to do with the handling of the materials prior to processing. I would like to address this part of my discussion to some of the aspects of usage of color concentrates and some of the problems associated with areas of mixing, moving and feeding of the concentrates and blended materials.

We must constantly be aware that one difference between the color concentrate and the natural pellets we are blending it with is the density, very often varying as much as two times that of the natural. This specifically must adjust our thinking, especially when designing airveying equipment for the transport of these products. Generally, we must think of twice the power necessary for moving concentrates than the natural product. The standard method is to provide holding tanks for natural and concentrate and then metering or weighing into a blending system. These units can vary from cement mixers, drum tumblers, conical blenders and metering devices as supplied by several manufacturers. The blending tumbler type device, although generally being the most efficient as far as obtaining an intimate mix, is not very efficient for high production rate. It is a batch method and can create human errors as far as weighing out materials is concerned.

The most consistent, as far as uniformity is concerned, are the various metering devices. This solves the human weighing problem and will provide a more consistent product for long continuous color runs. A problem can occur when short runs are being made and cleaning out of the pellets have to be done frequently.

The one problem which we must always keep in our minds is the final problem of transport. This is relative to the first property mentioned; the difference of the densities of the natural and masterbatch. When air transporting this material a distance, there is a tendency if run too far, to separate these materials. Also, if an improper stopping device like a poorly designed cyclone is provided, the spin of the material will cause a complete separation of the color concentrate from the natural resin. Therefore, properly designed stopping equipment is required at the hopper to insure the continual uniformity of the opacity of the finished product. This can be a double problem when two or more color concentrates are being used for blending a specific color. The air flow rate will have a tendency if not properly adjusted to cause a slight separation of the various materials. The ideal situation, of course, is to have your metering device at the hopper of the machine.

Another method being used at present is the installation of a motor driven wheel in the hopper of the machine rotating at a very slow rate.

In conclusion, one must be aware that the selection of a concentrate must not only be taken from the point of color, but also, what are the quality considerations. The uniformity and control many times are in the hands of the user and not of the concentrate manufacturer. His selection of blending equipment, transportation equipment and storage methods will contribute greatly to what he will see as an end product.

LIQUID DYES AND THE GROWING COLOR MARKET

Deran E. Altoonian

Marketing Division

Patent Chemicals, Inc.

Paterson, N. J.

ABSTRACT

The recent advances and developments in the plastics industry ~~are~~ increasing ~~the~~ potential for colorants that have brilliance, ease of formulation, and favorable economic factors. Fluid dyes are an important new advance in the field of colorants. The advantages as well as the disadvantages of fluid dyes are explored, and the distinct advantages are shown to far outweigh the disadvantages.

Color is an extraordinary medium of communication. Society lives in a world of color - be it color coded or fashion coordinated, and we of the plastics industry are aware of the importance of our role in keeping pace with the demands of our colorful world. The ever-increasing use of color is requiring our industry to improve the properties of the colorants in use today and to continue investigating the potential uses of color.

THE COLOR MARKET

The polypropylene market exemplifies the tremendous potential of the use of color. In 1967, about 650 million pounds of polypropylene were consumed by the manufacturers of the various end products of polypropylene (about 170 million pounds of this total were used for fiber products). The 1967 total is a 20 per cent increase over the 1966 consumption, which was 544 million pounds. Industry sources are hopeful that by 1970 polypropylene will achieve the billion-pounds-a-year status. Most of this will require colorants.

A. Polypropylene Fibers

Polypropylene fibers come in many forms: Continuous multifilaments, bulked continuous filament, tow, staple, ribbon and monofilaments, both flat and round. Polypropylene fiber has found diversified use in the carpet industry as face and backing yarns and as ropes, industrial bags, sandbags, decorative ribbons, tying and baler twine, fish nets and knit goods. At the present time, a large potential for polypropylene fibers is in carpeting.

The newest development with enormous market potential is in the use of slit polypropylene film instead of jute for carpet backing for outdoor and automotive use as well as for sandbags for military use. Polypropylene's great advantage over jute is its freedom from mildew and rot.

Synthetic fiber sandbag purchases are being stepped up by the military. In the first five months of 1968, contracts have been awarded and bids sent out for 330 million polypropylene sandbags and 112 million acrylic bags. Of the 500 million ordered last year, 165 million were made of polypropylene and the remainder were cotton and burlap. This is the first year acrylic bags are being bought; acrylics are more resistant to ultraviolet degradation than polypropylene.[1]

Almost all of the colored polypropylene carpet yarn being sold today is of the pigmented variety. Considerable efforts are being made, however, to perfect the solution dyeing process for polypropylene yarn.

A series of approaches in recent years toward solving polypropylene's lack of dyeability has led to the current method of adding to the polymer small amounts of polymeric cationic organic nitrogen compounds that act as dye receptors. In this use, polyvinyl pyridine derivatives appear to be gaining a predominant role. Reasonably good affinity for acid and disperse dyes has been the result of this development.[2]

B. Decorative Ribbons

One of the relatively new uses for polypropylene is for decorative ribbons. The total 1968 polypropylene market is estimated at 10 to 12 million pounds, with rayon fabric presently accounting for an additional five to eight million pounds. Polypropylene is rapidly replacing rayon for decorative ribbons, and current estimates foresee the use of 20 million pounds of polypropylene for decorative ribbon by 1970 - less than two years from today.

The breakdown of colorants used for polypropylene decorative ribbon is as follows:

Color	Per cent	Colorant types
Red	40	Dye
Green	25	Phthalo green
Yellow	20	Dye
Blue	5	Dye and phthalo blue
Fluorescents	5	Treated pigments
Miscellaneous other	5	Dyes

FLUID LIQUID DYES

An innovator in the use of anthraquinone dyes, which are used extensively for coloring a wide range of thermoplastic materials, is now the pioneer in the development of "fluid", or liquid oil-soluble dyes for use in the plastics industry.

This significant achievement was accomplished in the laboratories of Patent Chemicals, Inc., by Richard B. Orelup, the president of this company.

Patent Chemicals series of fluid liquid dyes offer many advantages to color formulators which heretofore have not been available. These advantages are the unique properties of high color strength, brilliance, transparency, and ease of formulation. An equally desirable advantage is their low cost.

These liquid dyes are uniform, liquid, oil-soluble dyes that are suitable for coloring polypropylene resin in all available forms, such as powder, beads and pellets. They are compatible in all proportions with most nonpolar and some polar solvents and resins, including synthetic hydrocarbon resins, aliphatic and aromatic hydrocarbons, esters, ketones, waxes or oils, fatty acids, and higher alcohols.

Fluid dyes contain a minor amount of aromatic solvent which acts as a viscosity depressant, and they are compatible with nonaqueous vehicles containing pigments or fillers. Fluid dyes do not affect the physical properties, tensile strength, or cause shrinkage of the polypropylene filaments. Also, these dyes do not precipitate degradation of the polymers. They also avert problems in pellet preparation, extrusion and draw-outs. Fluid dyes will have no adverse effect on the heat stability of the polymer. Under normal extrusion conditions, these dyes are stable up to 600°F.

A. Application Techniques

Fluid dyes can be utilized in many different methods for the coloring of resins.

Fluid dyes are added directly to the polymer, powder, beads, or pellets, depending on the color desired - from 0.05 per cent to one per cent in strength. This combination is then mixed in the usual manner until it is uniform. After the mixing cycle, the fluid is now ready to be extruded. Generally, any mixing equipment can be used, such as drum tumblers, ribbon blenders, paddle blenders, stationary augur mixes, conical vertical mixers, gravity blenders, double-cone and four-cone blenders, and twin-shell ("V") blenders.

A broad range of color concentrates can be made with fluid dyes on Banbury, twin-screw extruder, or two-roll mill.

B. Advantages of Fluid Dyes

Fluid dyes have many advantages. Some of them are:

1. In injection molding and the extrusion process, conventional equipment can be used,
2. less tumbling time,
3. slipping or surging problems are minimized,
4. homogenization is complete in very much shorter time due to high solubility and rapid diffusion in the resin melt,
5. fluid dyes disperse readily - no streaking or specking, freedom from screen-pack plugging due to poor dispersion,

6. combinations of fluid dyes and pigment can be readily compounded, and
7. high dollar value is obtained due to excellent relative tintorial strength.

C. Disadvantages of Fluid Dyes

The light-fastness of a dye varies with the concentration and often with the type of binder-plasticizer used. Although some of the colors have a tendency to bleed, this disadvantage is still acceptable for ribbon applications. Uses that require long-term freedom from migration would find fluid dyes unacceptable. Light stability is insufficient for outdoor exposure. However, Fadeometer and Weatherometer tests show that polypropylene ribbon colored with fluid dyes has sufficient stability to ultraviolet light and weathering to warrant the use of fluid dyes.

REFERENCES

1. Chemical Week, Market Letter, June 1, 1968, p. 30.

2. Honeycutt, E. M., "Polypropylene", Modern Plastics Encyclopedia, 45 (1A), 236, 1968.

o 4

DEHUMIDIFIED DRYING FOR PLASTICS

Dewey Rainville

Universal Dynamics Corp.

Some plastics materials are processed to serve man as sponges. These are found as an end product in supermarkets throughout the country. They do an excellent job of holding water on their surfaces and within their cells. Unfortunately, all plastics act as sponges to some degree, whether intended or not. This causes processors big troubles. It is about this problem - undesired moisture and how to remove it - that I am here to talk to you about today.

In the early years, plastics processors did not recognize moisture as a processing problem. One reason for this was the crudeness of primitive thermoplastics available during those years. Another reason was the fact that mold design and cylinder or barrel temperature control were in their infancy; any improvement over the control of heat transfer made such an improvement in cycle time that further reducing cycle times through moisture control was not considered.

Nevertheless, chemists of material suppliers recognized that, in theory at least, minute quantities of water on or in their products might prove a source of difficulty. It came as no real surprise to them when in the early 1950s, processors began complaining that certain splay marks and discolorations could no longer be eliminated by venting molds, changing die designs, or using the latest mold temperature controls. Laboratory tests were conducted and they confirmed the need for removing moisture from many new materials.

The first devices designed for this purpose were simple hot air pumps. These primitive hopper dryers pushed hot air over the material and evaporated surface moisture. Removal of surface moisture was adequate to solve the problem. It also provided very welcome side benefits.

Preheating resulted in more uniform and elevated material temperatures at the hopper discharge; as a result, processing machines had less work to do for the same end result. A reservoir of potential was created that could be applied to increasing processing rates or applied to reducing machinery load and wear factors. Another benefit was the ability to take cold material out of an unheated storage facility and throw it on top of room temperature material in a hopper without disrupting the equilibrium of the processing equipment.

However, it was soon found that not all materials responded to this treatment as hoped for. Certain materials contained sufficient internal moisture to interfere with processing, and this internal moisture could not be removed by a simple wiping with hot air. Some means had to be found of increasing the vapor barrier differential. Put another way, some means had to be found to make the air around and inside a plastics granule so dry that water molecules within the

granule would have to leave the granule in order to reach a point of equilibrium with the surrounding air. The greater the water vapor pressure within the granule compared to the surrounding air, the more complete and rapid the migration of water molecules from the granule to the surrounding air.

As a manufacturer and distributor of drying equipment, we became vitally interested in this problem. So much so, in fact, that in 1958 we had a series of material drying tests run in our Long Island laboratory.

Before I detail the results of these tests, and of others subsequently conducted here and abroad, I am going to briefly explain some necessary terms that occasionally cause trouble after one has successfully passed their physics finals.

Removing moisture from a "wet" plastics involves a change in dew point. What does dew point mean? We are all familiar with moisture condensing on the surface of a cold glass, and with moisture condensing on grass during the cool of night. In both cases, moisture leaves the surrounding warm air as the air temperature is lowered. Obviously, when air is cooled, its ability to hold moisture is lessened. If air is cooled beyond a certain point, the so-called dew point, moisture drops out of the air.

The maximum amount of moisture that air can hold at any given temperature has been determined. When air contains the maximum for a given temperature it is said to be saturated. When air is not saturated, it can contain more water. Because unsaturated air can contain more moisture, there always exists a potential for it to do so. It is this potential of unsaturated air to absorb moisture that is called on to dry plastics materials.

One more point to remember about air is how its degree of dryness is rated. As we have seen, the dew point of air at a given temperature is related to fully saturated air at the same temperature. In other words, how much moisture is in a given volume of air at a given temperature. Since dew point is related to a specific amount of water, it is convenient to describe the amount of moisture in air in terms of dew point. For example, air at 175°F might contain only as much moisture as would saturated air at -30°F. This would be indicated by simply stating "this air has a dew point of -30°F".

So much for terms. We elected to run our test on nylons, which at that time was as difficult a material to handle as could be found. Our test equipment consisted of a large 40-tray oven connected to a standard commercial dehumidifier. In this fashion we controlled both the temperature of the nylon and the moisture of its environment. Incidentally, the tests were run during one of those hot, humid, Long Island summers.

Beginning with the first tests, it was immediately apparent that the drying time for nylon could be considerably reduced by using hot, dehumidified air. Furthermore, the shorter, more effective drying times also eliminated the problem of discolored nylon. Dehumidifying the air was a giant step forward in solving the vexing problem of drying nylon and other materials that absorb water into the plastics granule.

Since our first tests, we have evolved a line of compact hopper dryers containing their own dehumidifiers. The several slides that follow show drying curves developed using this compact, modern equipment (see Figure 1).

POLYSULFONE RESIN

This curve illustrates the fact that in drying, air temperature directly affects the rate at which moisture is removed, whereas the dew point affects the ultimate minimum moisture level reached. At the start of the test, there existed a considerable differential between the drying air temperature and the plastics. At this point, moisture was rapidly removed, and when the air temperature was increased, the quantity of water removed was significantly increased. But as the differential between air and material temperatures narrowed, the drying rate slowed down. To further reduce the material moisture content once the equilibrium state had been reached would have required lowering the dew point of the drying air.

BLACK POLYETHYLENE

The curve in Figure 2 is representative of a more difficult drying problem because carbon black is quite tenacious toward water. Nevertheless, at the end of two hours the material was sufficiently dry to extrude as a sheath for telephone cable. Incidentally, you will note that there apparently existed a variation in material moisture content after two hours. I say, apparently, because most materials can be dried to a point where it is impossible to get consistent moisture analysis without the use of exacting chemical techniques and trained technicians. At low moisture contents, seconds count between taking a sample and subjecting it to analysis because the super dry material will instantly pick up moisture from the air.

LEXAN POLYCARBONATE RESIN

The curve in Figure 3 again demonstrates that for most materials a drying time of two hours in dehumidified air suffices.

Figures 1, 2 and 3 dealt with only three materials. But as we all know, the plastics industry is aggressively competing with the established materials of steel, glass, wood, aluminum, etc. This competition has resulted in a host of materials such as ABS, acrylic, acetate, butyrate, polycarbonates, nylon, polysulfone - all of these materials absorb moisture. Some of these materials have exacting drying requirements. For example, you can't mold nylon if it's "wet". On the other hand, if you get it too dry, it loses its strength. You can mold ABS into a perfectly usable part, but unless the material was dry enough when molded, it won't hold a chrome plate. Some plastics, when subjected to elevated temperatures, seem to release volatiles, other than water, that cause problems closely resembling too much water in the material.

Only two things are certain about drying plastics materials. One, the moisture content within a plastics granule can best be controlled by combining heat and dehumidified air; and, two, the machinery manufacturer must be able to develop machinery suited to both new materials and the challenging economic situation of today. As machinery manufacturers we are keenly interested in doing the former efficiently and designing devices for the latter.

Some of the new drying machines being produced today are a clear indicator of future trends in the plastics industry and I will discuss them briefly. First, and perhaps of most immediate interest, are the so-called mini-dryers.

Mini-dryers are dryers designed to do both the work of an ordinary hopper dryer and an oven at prices competitive to an oven-dehumidifier combination. These dryers can handle stocks of non-compatible materials and colors at the same time. The basic mini-dryer consists of a hopper dryer with a desiccate cartridge in the system and a separate heating device to cook out the cartridge when it is wet. The capacity of the cartridge cook-out device far exceeds the needs of one mini-dryer. Therefore, four mini-dryers can be mounted on a common, portable, frame. Four mini-dryers so mounted have the same drying capacity as a forty-tray oven, as well as the capability of drying four materials simultaneously.

This capability to dry different materials simultaneously is extremely important when non-compatible materials such as nylon and butyrate are involved. Also, materials having completely different drying properties can be simultaneously handled by mini-dryers but not by ovens.

In fact, if one considers that drying non-compatible materials in ovens requires either more than one oven or cycling the materials separately, then a mini-dryer package is equivalent to four separate ovens with four separate temperature controls.

Another advantage to the mini-dryer package is ease of material handling. There is no need to remove forty trays from an oven in order to charge them with material, no need to replace the forty trays, and no need to remove forty, hot, charged trays. Material spillage is virtually eliminated by the mini-dryer package. Direct labor costs are greatly reduced.

These factors, flexibility of drying temperatures, ability to dry four non-compatible materials at the same time, reduced labor costs, cleanliness, portability, and low capital investment, lead us to conclude that ovens, like dinosaurs, are obsolete.

Let us go from the small to the large. Like most industries, the plastics industry is witnessing the growth of the larger company and the demise or merger of the smaller company. Large companies have large appetites and it is only logical that they purchase and store material in bulk. A growing trend in bulk storage is outdoor storage in silos.

But some of the advantages to silo storage disappear when materials become water contaminated due to moisture condensation within the silo or due to moisture absorption.

Both of these problems are controllable by making the silo part of a loosely-closed air system incorporating a dehumidifier. Blowing dehumidified air into the silo creates a positive pressure, dry air environment within the silo. Air leakage is to the outside atmosphere. Make-up air is dried before introduction into the silo.

Operating such an inexpensive system 24 hours a day prevents moisture absorption and removes surface moisture brought in with fresh material. Extensive use of silos can be expected in the future.

The hopper shown in Figure 4 in conjunction with the appropriate dryer, is capable of drying 1,000 lbs. per hour of ABS material to a moisture content of 0.02 per cent by weight.

The same arrangement can handle 3,000 lbs. per hour of 30 per cent carbon-

filled polyethylene. It is quite in keeping with the growth of our industry that only two years ago, drying 500 lbs. per hour of such materials was an almost impossible application engineering problem.

I have reserved for last what is to me today's most exciting development in the drying field, namely, the drying of powdered material. After five years of development, our Una-Dyn division has developed and patented the first practical and inexpensive desiccate type powder dryer-dehumidifier. These powder dryers provide the thermoplastic processor with yet another tool for controlling the physical state of materials used in extrusion, injection molding, and rotational molding. And, it should be noted, in some instances there is a significant price advantage to purchasing and processing thermoplastic powders.

To summarize: The art of drying thermoplastic materials has kept pace with material developments. From the early days when a dryer was only expected to surface dry a hundred pounds or less per hour have evolved dryer-dehumidfiers capable of efficiently drying a ton or more per hour of highly hygroscopic material. From the crude and inconvenient oven has been developed multiple drying systems that cost less than an oven, can simultaneously handle materials requiring different drying temperatures, and which can be made part of the automatic material handling processes so common today. We have seen that there is available the equipment to economically keep dry and uncontaminated bulk storage facilities. And finally, we can see ourselves entering the era where the advantages of regularly using powdered plastics materials will be common-place.

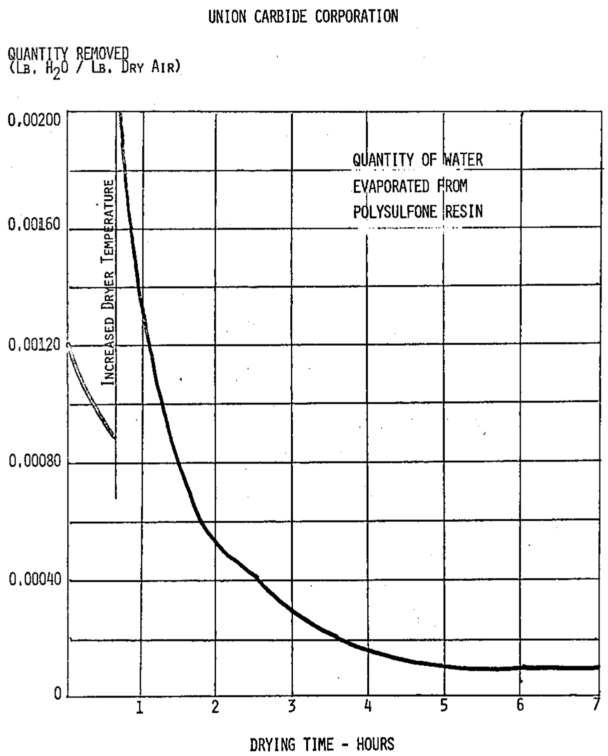

FIGURE 1 Polysulfone Resin

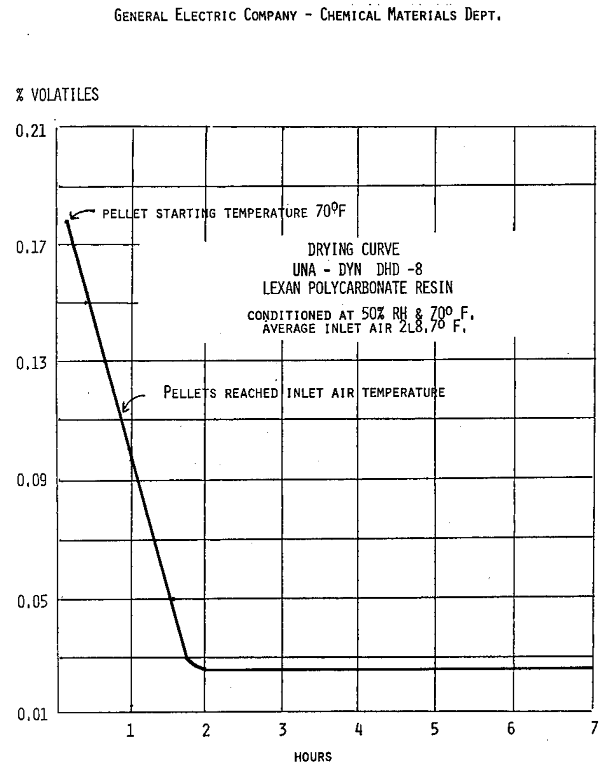

FIGURE 3 LEXAN Polycarbonate Resin

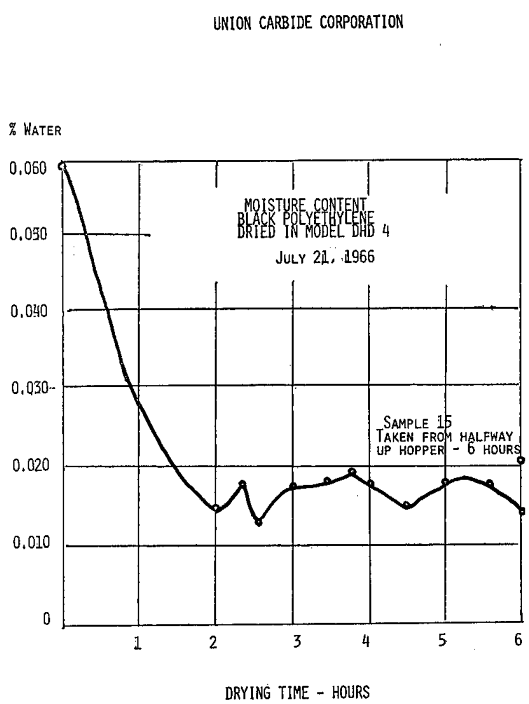

FIGURE 2 Black Polyethylene

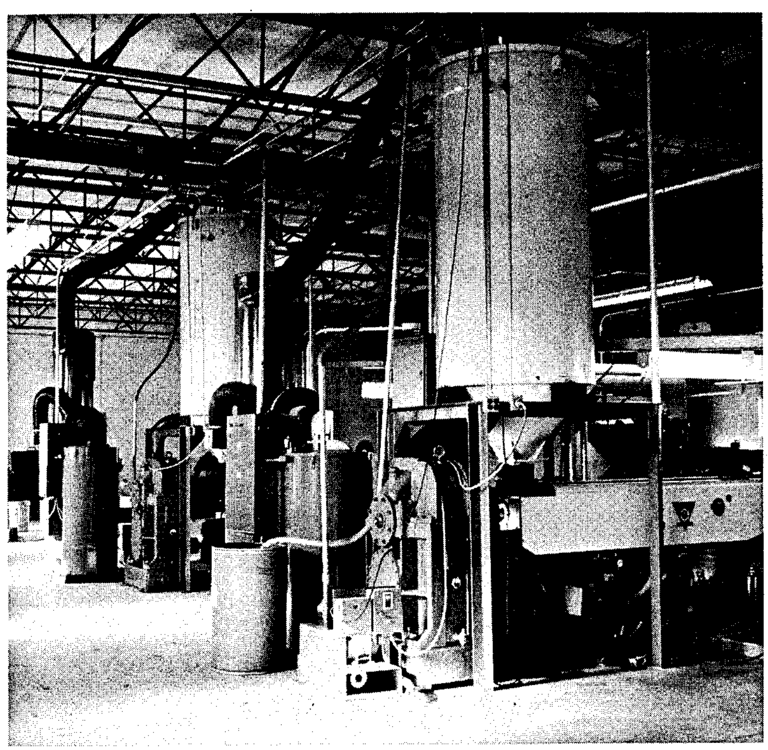

FIGURE 4 DHD 25 Hopper

-05

REYNOLDS NUMBER ANALYSIS OF HEAT TRANSFER IN THE MOLD

C. E. Waters

Application Engineering Corp.

Elk Grove Village, Ill.

INTRODUCTION

Experience with heat transfer from molten plastics to coolant passages in plastics molds has revealed the need for additional investigation into the relationships between tube velocity, tube configuration, viscosity of fluid, and configuration of heat transfer surfaces within the mold.

In order to develop theoretical concepts that would furnish a sound basis for the design of mold heat transfer passages, Dr. H. A. Simon, Associate Professor, Department of Energy Engineering, University of Illinois, and Mr. Otto Doubek, Heat Transfer Engineer on the staff of Application Engineering Corporation, have conducted the analysis discussed in this paper.

REYNOLDS NUMBER

The starting point for this analysis is the Reynolds number - a dimensionless ratio used in predicting changes in the flow characteristics of fluid. As applied to liquids, the Reynolds number formula is as follows:

$$R = \frac{dvp}{\mu} = \frac{dv}{V},$$

where

d = pipe diameter (ft.),
v = average velocity (ft./sec.),
p = density (slugs/cu.ft.),
μ = viscosity (slugs/ft.sec.), and
V = kinematic viscosity (sq.ft./sec.)

This formula was applied in the analysis conducted for two coolants - water and ethylene glycol (50/50 mixture with water by weight) for tube diameters of 11/32 in. and 7/16 in., assumed to have constant properties.

Reynolds numbers were calculated for these liquids at the temperatures and conditions described below.

Temp., ^{o}F	p lb/ft	ν x10 ft /sec.	K Btu/hr. ft F.	Pr.
32	62.57	1.925	.319	13.6
50	62.525	1.40	.334	9.6
(50/50 solution)				
20	67.36	10.48	.248	76.8
32	67.18	7.5	.247	55.8
50	66.86	5.13	.246	38.92

The Reynolds number of a liquid rises with its velocity, its temperature and an increase in the size of the diameter of the pipe through which it flows. It decreases with the viscosity of the liquid.

In order to simplify our discussion, let's eliminate one variable - viscosity - by considering each liquid separately.

When we look at the relationships in the Reynolds number ratio, we can begin to draw a few basic conclusions. Apparently, there are three ways in which we can increase the Reynolds number of a specific cooling fluid. First, we can design our molds with larger passages. This is easier said than done, since, as a rule, mold-passage size must be modified in the interests of over-all mold design considerations. Second, we can increase the velocity of the coolant in the tubes. This is somewhat easier to accomplish by means of pumping, but - and this is a big but - the boosting of pump capacity presents a number of practical problems that we'll consider later on. Third, we can increase the temperature of our cooling water. Actually, the 50°F leaving water temperature for most water chilling systems used in the plastics industry is high enough if the remaining elements in our Reynolds number analysis are calculated correctly.

Before we analyze these three factors further, let's look at viscosity briefly. Many water chilling applications use a 50/50 solution of water and ethylene glycol as a coolant.

It is immediately apparent from the Reynolds number formula that the increased viscosity of the 50/50 solution lowers the Reynolds number, other factors being equal.

Let's make a comparison of a 50/50 solution and water under parallel conditions. Assume that both are at a temperature of 50°F and flowing through a 7/16 in. diameter tube. We'll base our calculations on a velocity of two ft./sec.

Under these conditions, the Reynolds number of the 50/50 solution is 1,400. The Reynolds number of water is 5,000.

If we want to raise the Reynolds number of the 50/50 solution to 5,000, we have to increase its velocity to 7.1 ft./sec. under the conditions we have described.

At this point, it's important to consider the physical characteristics of the liquid flowing through the tube. Flow can be laminar or turbulent. Laminar flow can be considered as straight line flow, with the water in layers parallel to the pipe wall. The layer of water adjacent to the pipe wall constitutes a slow-moving film. As we move to the midpoint of the flow, the layers between the wall and the midpoint move progressively faster. In effect, each layer from the wall to the midpoint acts as an insulator, reducing heat transfer from the

mold to the stream of water.

We can overcome this insulating effect by creating turbulent flow, which destroys the laminar pattern.

Flow changes from laminar to turbulent with an increase in velocity or with an increase in pressure drop.

Actually, there are three flow conditions - laminar, transitional from laminar to turbulent and turbulent. Let's relate this to the Reynolds number. Once again, we'll use our example of a coolant at 50°F flowing through a 7/16 in. pipe.

We find that for water under conditions of fully developed flow, turbulent flow is achieved at a velocity of about 1.15 ft./sec. and a pressure drop of about .0105 lb./sq.in./ft. length of pipe.

The Reynolds number corresponding to this set of conditions is about 1,800.

Now let's consider the pressure drop and velocity relationships for full developed flow of the 50/50 solution. Once again, using the 50°F temperature and the 7/16 in. pipe, we find that turbulent flow begins at a velocity of 2.9 ft./sec. and a pressure drop of .01725 lb./sq.in./ft.

Referring to Figure 2, we find that the Reynolds number corresponding to these conditions is in the neighborhood of 2,000. By repeating these comparisons for many sets of conditions, it is possible to conclude that laminar flow is characteristic of Reynolds numbers of 2,000 or less. For the sake of a substantial safety factor, we can assume that Reynolds numbers of 2,000 to 4,000 are transitional from laminar to turbulent, and that Reynolds numbers of 4,000 or more certainly involve turbulent flow.

How does all of this tie in with heat transfer? Let's consider the heat transfer coefficient in Btu/hr.ft.^{2} °F for fully developed flow of water. Calculations used to plot curves for laminar flow reveal a straight line situation. So long as flow is laminar, an increase in velocity does not produce an increase in heat transfer.

But heat transfer begins to rise markedly with velocity when flow becomes turbulent. The rise eventually tends to level off as velocity continues to increase, so apparently there is a point of diminishing returns so far as velocity is concerned.

Performing the same analysis for fully developed flow of the 50/50 solution, we see that the same basic conditions apply, relatively speaking. The essential difference is a shift in velocity to higher levels required for achieving turbulent flow.

Once again, we come back to the Reynolds number. At a Reynolds number of 4,000 or more, we have the turbulent conditions conducive to good heat transfer.

Let's return once more to our example of a 50/50 solution flowing through a 7/16 in. pipe at 50°F. We find that a Reynolds number of 4,000 involves a velocity of about six ft./sec. A velocity of six ft./sec. results in a heat transfer of 420 Btu/hr.ft.^{2}°F.

We've reached a very important point here, since we have a definite heat transfer figure based upon the Reynolds number, which, in turn, reflects all of the relevant characteristics of the coolant and the dimensions of cooling passage.

Before we leave this aspect of our discussion, another important consideration - entrance length - must be taken into account. We have been speaking of fully developed flow which may be an unfamiliar term. Flow patterns are not established immediately when liquid enters a pipe. Actually, the length of a pipe can be divided into two portions - entrance length and final length.

Engrance length conditions tend to reduce heat transfer. Therefore, the entrance length must be calculated in determining over-all heat transfer characteristics.

The formula for laminar entrance length is

$$Nu = 1.86\ (Re\ Pr)^{1/3}(\frac{d}{L})^{1/3}\ .$$

The formula for turbulent entrance length is:

$$Nu = 0.027\ Re^{0.8}Pr^{1/3}(\frac{d}{L})^{.055} \quad \text{for } 10 < \frac{L}{d} < 400\ .$$

For our calculations, entrance length was taken as two ft.

There's one more important consideration - that of parallel pipes below a constant temperature surface.

Here a graphical network analysis was applied to a single pitch for various values of the variables P/d and D/d, as illustrated in Figure 1.

Our results are obtained from

$$q = \frac{(T_s - T_b)}{\frac{1}{Sk} + \frac{1}{dh}} \text{ Btu/hr. per single pitch per unit length of die}$$

where

T_s = surface temperature,

T_b = fluid bulk temperature, and

S = shape factor.

In order to obtain total heat transferred, Q must be multiplied by the temperature difference ($T_s - T_b$) and the number of complete pitches, P. In making our calculations, we assumed thermal conductivity of the solid as being 25 Btu/hr.ft.^{2}^{o}F.

1. At fixed P/d, reduction of depth is most effective at high heat transfer coefficients (i.e., if heat transfer coefficient is less than a certain value it may not be worthwhile striving to reduce the depth).

2. At fixed P/d increase of heat transfer coefficient is more effective at small D/d (i.e., if depth is greater than a certain value, it may not pay to increase heat transfer coefficient).

These results are not surprising. The heat transferred per pitch unit time and unit length expression shows that if $\frac{1}{SK} \ll \frac{1}{dh}$, increasing S will be beneficial rather than h. Further, since at fixed D/d, S is some function of P/d, decreasing P/d leads to a proportional increase of q when $\frac{1}{SK} \ll \frac{1}{dh}$ but the effectiveness of the decrease becomes less for $\frac{1}{SK} \gg \frac{1}{dh}$.

.60

MOLD TEMPERATURE CONTROL - HEATING

Joe D. Robertson

Process Control Corporation

Atlanta, Ga.

Molding machines today are highly instrumented and controlled, and the trend is for even more sophisticated control for the precision work required in many molding applications. It is, therefore, becoming extremely important for auxiliary control equipment to keep pace with the industry.

In the case of mold temperature control equipment, the areas of greatest importance are accuracy of control, efficiency of heat transfer, and dependability. The function of the controller, of course, is to hold an injection mold at a constant temperature, normally ranging from as low as 30°F to as high as 350°F., determined by the material being used and the design of the part. Since the controller must maintain a selected temperature, whether the mold requires heat input or heat removal, there must be both a heating and a cooling circuit in the controller. The accuracy of control demanded by today's sophisticated new materials and closer tolerances, cannot adequately be accomplished with conventional on-off control.

A typical on-off controller utilizes a temperature sensing element to activate a heater for the heating cycle, or to open a solenoid valve for the cooling cycle. With this type design, the heater is either full on or full off, the solenoid cooling valve is either full open or full closed, or the temperature is in the null zone range with neither heating nor cooling required of the unit. With heating or cooling required, this type system produces a control curve typical of that shown in Figure 1. On start-up, the heater is on until the temperature reaches a point approximately two to three degrees F. below set point temperature. At this point, the heater is automatically turned off, but the temperature of the fluid continues to rise due to thermal override, typical in any heating system and caused primarily by the hotter mass of metal in the heater. At this point in the cycle, if the mold still demands heat the fluid temperature will drop, once again activating the heater; however, at a temperature approximately 2 degrees lower than the heater off point, this being the approximate travel necessary to activate the microswitch controlling the heater. Again there will be some thermal override allowing the fluid temperature to drop still further before the heater can overcome the inertia of the system.

Going back to the point where the heater is turned off, if a molding condition exists requiring heat removal from the mold, the fluid temperature will continue to rise after the heater is turned off until a level is reached at which the solenoid valve is opened to allow an in-rush of cooling liquid to the system. This occurs at a point approximately four to five degrees above set point. The solenoid valve closes after a drop of approximately two degrees F., this again being the travel

necessary to activate the control microswitch. Since there will probably be cold areas in the system where the last bit of cooling fluid is introduced, there will be a tendency for a further temperature drop as this cooling fluid is dispersed.

The amount of thermal override for a given controller varies with the heating or cooling load imposed by the mold. Since this lag varies from mold to mold, a generous null zone must be allowed for an on-off system of this type, this null zone being the temperature span between the heater off point and the cooling valve open point, usually a minimum of six to eight degrees F. This rather generous null zone is necessary to prevent a condition wherein the thermal lag will carry the fluid temperature from the heater off point, up to the cooling valve open point, which would cause rather wild fluctuations in the fluid temperature. Such a condition is commonly referred to as "bucking", and results in an intolerable swing in fluid temperature.

To overcome the disadvantages of this on-off system, a different type of control is required. A completely stepless control for both heating and cooling would be ideal, however, such a highly sophisticated system is probably impractical at this time primarily from cost and space considerations. It is, however, realistic to approach solving the problem by providing a stepless control of the cooling function with on-off control of the heating function. To accomplish this, a controller with a mercury filled thermal sensing element is used, with this element being used to actuate both the heating and cooling function. A small piston is integral with the mercury element and actuates the heater on-off switch as well as operating directly on a modulating cooling valve. A typical cycle from start-up with this type system would produce a curve as shown in Figure 2. As with the on-off controller, the heater is full on if heat is required on start-up and turned off automatically at a predetermined temperature slightly below set point, but the temperature will tend to rise further due to thermal override. At this point, the fluid temperature will rise still further if the mold needs cooling or drop if the mold demands heat. If cooling is required and the temperature of the fluid continues to rise, the mercury column in the controller continues to expand and the small piston begins to open the cooling valve when set point temperature is reached. At first, the valve just cracks open admitting a slight amount of cooling water; however, if the temperature continues to rise, the valve opens more and more until just exactly the right amount of cooling water is being introduced at a constant rate to balance the amount of heat being added to the fluid by the mold. Consequently, the temperature no longer fluctuates, but remains absolutely constant. This absolute balance between the cooling required by the mold and the cooling fluid introduced by the valve, eliminates the sawtooth curve on the cooling function. The actual temperature of the circulating fluid will settle out and be controlled very accurately at a temperature slightly higher than the set point temperature. However, the temperature itself is read by a separate thermometer and a slight adjustment can be made to obtain any desired temperature.

Since thermal override has been eliminated from the cooling function, it is now possible to virtually eliminate the null zone. Thermal override will still exist on the heating function; however, now if the load is small, making the override great enough to raise the fluid temperature above set point, the cooling valve will just slightly crack, introducing a small amount of cooling liquid but only enough in any instance to bring the fluid temperature down to set point. This produces a self dampening condition and eliminates the wild swings in temperature experienced with the on-off controller in such a situation; but instead, controls the fluid temperature very accurately at a level close to set point.

Accurately controlling the temperature of the heat transfer fluid is only a

part of the function of a mold temperature controller. The other functions involve transferring heat between the mold and circulating fluid with the maximum possible efficiency and then handling this heat load with a minimum temperature differential across the mold. These functions can be effectively accomplished if a sufficient volume of fluid is supplied to the mold at a pressure high enough to assure turbulent flow in the mold channels and obtain the maximum amount of circulating fluid throughput.

The obtaining of turbulent flow is essential for good efficiency in transferring heat between the mold and the circulating liquid. Furthermore, a high circulating rate minimizes the temperature difference from point to point in the mold, this temperature difference being inversely proportional to the throughput rate. Consequently, high pumping rate and adequate pressures are essential for efficient operation.

The most accurate and efficient controller is of no value unless it operates reliably. It is intolerable for very expensive injection molding machines to be tied up because a piece of auxiliary equipment has malfunctioned. It is essential, therefore, that comprehensive engineering be coupled with quality workmanship in the production of auxiliary equipment to provide machines that are virtually foolproof. If the mold temperature controller is activated with an insufficient supply of water two major areas of damage will occur, these being the pump seals and heater. It is unrealistic to expect plant personnel to never make a mistake when starting up equipment. Therefore, it is the controller manufacturer's responsibility to engineer and supply safety interlocks to prevent such mistakes causing damage to the machine. Failsafe features should also be provided; for instance, an interlock to cut out the heater in the event power is disrupted to the pump.

It is also important to insure that dirt in the water supply system is not introduced to the controller or to the mold, which can be accomplished with strainers in the water supply line in the circulating system. Even with adequate strainers, it is still possible for dirt to be present in a mold or for scale, which has formed in the mold, to break loose and obstruct the water passages. In this event, the mold temperature controller should be designed to prevent excessive temperatures or pressures.

A mold temperature controller, like all good accessory equipment, should be designed and built so that it can be set, started and forgotten.

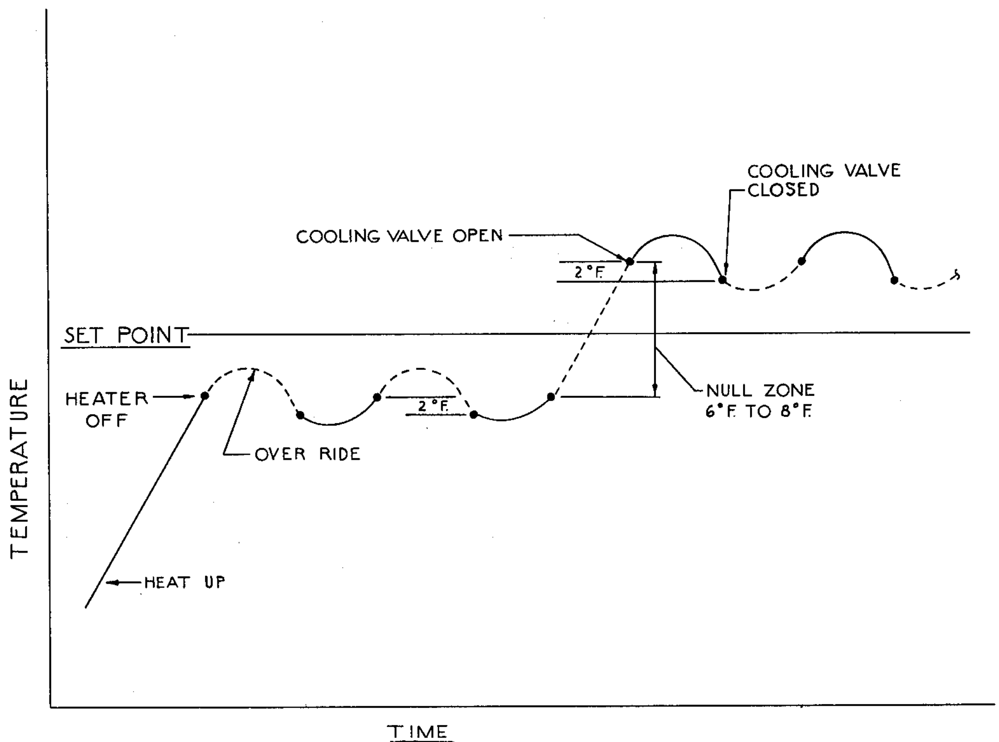

FIGURE 1

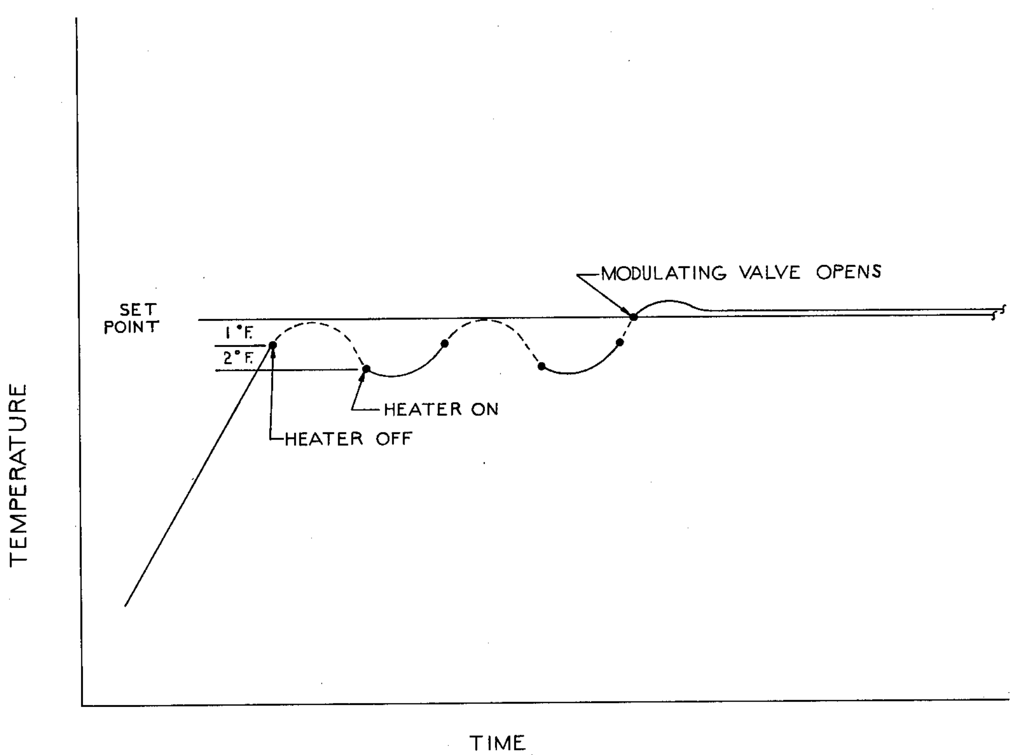

FIGURE 2

.61

AUTOMATED GRANULATING SYSTEMS FOR INJECTION MOLDERS

Fred M. Smith

Cumberland Engineering Co., Inc.

Providence, R. I.

ABSTRACT

The growth of automation in industry during recent years has had resounding effects in the production of innumerable products. The plastics industry, which has shown a phenomenal increase in market acceptability in all phases of its production, has been in the forefront in the development of automatic handling equipment.

This paper deals with only one segment of the plastics industry, that of the injection molder, and describes the approach Cumberland Engineering ~~Co. has~~ taken to fill a need in this area of the industry. The paper touches briefly on earlier methods of handling and grinding reclaim materials, and takes us through to the present with a detailed discussion of "beside-the-press" and "under-the-press" granulators. Also discussed are such ~~important~~ features as mobility of the granulators, ~~and~~ ease of changing screens, ~~as well as~~ ease of cleaning the machines and changing or adjusting knives.
and

this
In closing, ~~the~~ paper warns that each plant must have a careful assessment made of its basic operation before embarking on an automated program. It also points out several areas in which improvement can be made and promises continued efforts will be made to implement these improvements.

In recent years there has been a rapid trend toward automation in industry throughout our country and other industrialized nations of the world. Since the plastics industry is probably the most dynamic industry in the world today, it is no small wonder that automation in plastics should become of such great importance. Of such importance and interest that today technical papers on this subject are solicited and considered necessary to round out the full scope of plastics processing, especially for those engaged in injection molding.

When we look at the broad spectrum of plastics processing, including injection molding, profile and pipe extrusion, sheet extrusion, blow molding, rotational molding, thermoforming, and all the other phases of plastics production, I am sure you will agree that comparatively, the quantity and variety of items produced by the injection molder per minute and the highly competitive market in which he operates, places him in as great, if not greater, need for automation than any other phase of our industry.

Those who have been actively engaged in injection molding for the past 10 to 15 years have seen many changes take place in molding techniques such as mold design, larger molding machines capable of producing larger and heavier molded parts, new materials such as polypropylene, ABS resins, polycarbonate, glass filled polycarbonate, glass filled nylon, polysulphones and others which are currently being developed.

While all these developments have had quite an impact on the injection molder, there is no doubt that it has had equally as great an impact on the manufacturers of accessory equipment, particularly those of us engaged in the manufacture of granulating equipment.

In the era of from 15 to 20 years ago, the most popular thermoplastic materials were polystyrene and cellulose acetate. Very few large parts were produced, and as a result, small-throat, low-horsepower granulators were equal to the task. In many instances, the use of a granulating machine for small polystyrene sprues and runners was not required as the operator was able to break these into small pieces and feed them back into the injection machine hopper to blend with the virgin material.

However, with the changes and progress in the industry, new designs of granulators providing larger throat sizes, heavier construction and greater horsepower with a minimum of floor space have been necessary. Early designs provided for a two-stage granulator which utilized a large throat pre-breaker section powered by a 30 hp motor and in which a large-size screen was installed. This unit was mounted on a common base with a granulating unit powered by a 10 hp motor which received the chopper material from the prebreaker. The granulating section provided the final granulation and discharged by gravity into a drum or some other suitable receptacle.

This was not the most desirable method of reducing scrap and was eventually replaced by the large-throat, heavy-duty granulators available today. These are generally used by the injection molder who uses large quantities of the same color of a given material such as those engaged in the molding of pipe fittings, ladies' shoe heels, housewares, etc. These granulators with throat sizes of up to 20 in. x 50 in. and powered with motors of 100 hp and more are generally located away from the molding area. This type of granulating is called "central granulating". Needless to say, these granulators must be of very rugged construction since operators tend to overfeed, air shots or bleeder scrap is often allowed to build up to ungainly size and last but not least, scrap metal, cutters and wrenches have a way of finding their way into material waiting to be granulated. All of these are very demanding on a granulator and usually a machine of this type has a greater capacity in pounds per hour than may be required. However, ruggedness, throat size and horsepower are the prime requisites when considering a machine for central granulating.

Automation has created the need for "beside-the-press" and "under-the-press" granulators. To answer this requirement of the injection molder, Cumberland Engineering Co. has developed the Cumberland Automated Preparatory Systems, commonly called "CAP" Systems which provide a means to handling sprues, runners and rejected parts automatically. The method used to introduce scrap into the system is usually determined by the size of the runner system. The balance of the process and control of the system, including granulating, blending and return to the injection press, is achieved by the use of standard components.

Where there is fast cycle molding with the automatic degating and separation

of molded parts from the sprue and runner, the sprues and runners are automatically charged to a Cumberland plastics granulating machine. In one case, the runner system drops directly into an auger feed granulator that is mounted in the bed of the press directly under the mold area. However, if space limitations prevent installation in bed of press, scrap can easily be conveyed to that side of the press most convenient for positioning of the granulator.

Figure 1 shows the auger design of "under-the-press" granulator.* This figure shows the Cumberland Model "O" fitted with an auger feed which transfers the sprues and runners from below the die area into the cutting chamber. Standard components have been used in the design of this machine. The bearing housing, rotor knives, screen and cutting chamber housings are identical in design to those standard Model "O" granulators now in service in many injection molding shops. This provides for interchangeability of knives, screens and bearings which minimizes the stocking of spare parts for those who are already using machines of this design.

This is a very compact design. The overall dimensions are approximately three ft. long by two ft. high and about 14 in. wide. It is powered by a 3 hp double-shafted motor. One motor shaft is directly coupled to the granulator rotor, the other drives the auger through "V" belts and a gear speed reducer providing an auger speed of about 40 rpm.

The hopper tray length is variable to suit individual application requirements. The angle of slope of the tray is usually dictated by the relative height of the die area in the injection machine. The method of removal of the granulated material from the discharge transition piece is optional. This slide shows outlets for vacuum loaders. However, other type blowers similar to Sterling or Roots-Connersville may be used. Generally speaking, the latter two types require more space and in many cases a separator is required to separate the material from the air at the point of collection.

Figure 2 shows the same unit except that it is assembled with the opposite hand configuration.* These units are caster mounted to provide mobility for the transfer of the granulator from one injection machine to another.

Figure 3 shows an end view of the auger type granulator indicating the compactness of design which is very important to those who have problems with lack of floor space.*

Figure 4 shows the ease with which this design of granulator is dismantled for cleaning and knife change or adjustment.* This is accomplished by loosening two hex nuts, one on either side of the cutting chamber housing. The swing bolts drop down enabling you to slide the end housings out from under the auger, exposing the rotor. The rotor is ground all over for accuracy and ease of cleaning. The screen is removed by first backing off one dog point screw and then lifting the screen out through the too or large open area of the lower housing.

Figure 5 shows a Cumberland Model 1012 granulator also arranged to fit in the bed of an injection molding machine.* The feed entrance to this machine is air operated so that its opening and closing can be controlled and synchronized with the cycle of the injection molding machine. The opening to the granulator section opens only to receive the automatically degated sprue and runner system. This unit has a special down draft suction to prevent granulated material from

*Figures not available at date of publication.

getting into the open die area. It is powered by a 5 hp - 1800 rpm motor and with standard sheave and belt combinations a rotor speed of approximately 700 rpm is obtained. Although Figure 5 shows a 10 in. x 12 in. throat size, this same design is available in throat sizes of 8 in. x 10 in. - 10 in. x 16 in. - 14 in. x 16 in. - 14 in. x 20 in. Except for the 8 in. x 10 in. throat size, these units are supplied with end removable screens which are removed through the opening in the end plate in the cutting chamber provided for that purpose. The clam shell hopper doors are spring loaded to insure closing after the sprue and runner system have passed into the cutting chamber. A two-knife hollow rotor is installed. This insures adequate air flow through the cutting chamber reducing the danger of fly-back and also providing a constant flow of air through the granulator to convey the granules to the collecting area. The clam shell or hopper doors are actuated by an air cylinder which is controlled by an electrically operated air valve. This valve is synchronized with the stroke of the injection molding machine. To insure a continuous flow of air, a screen is installed in the side of the hopper. This unit is quite compact, requiring approximately a floor area of approximately 24 in. x 42 in. The granulated material can be collected by a blower, the transition piece for which is shown in Figure 5 or by a vacuum loader.

Figure 6 shows the same model open for cleaning and knife changing or setting.* It is opened by loosening one clamp and swinging the hopper to the side. It is also necessary to remove the fulcrum pin from the air cylinder. With the hopper swinging to the side, complete access to the knife and bed knife adjusting screws is provided.

Figure 7 shows the Cumberland #1012 CAP system which consists of a 1012 throat granulator equipped with a two-knife hollow rotor, Sterling Blower, combination virgin pellet hopper and vibratory feeder.* This design is also available in throat sizes up to 14 in. x 20 in. The virgin material hopper is supplied with a vacuum loader which maintains a constant level of virgin material in the hopper. It is discharged and metered into the air stream that is moving granulated scrap into the injection machine hopper or blender.

While this figure shows a blower mounted on the discharge for conveying to the collecting area, a vacuum loader or other type of airveying unit may be used. This is the option of the molder or user of the system. The virgin resin rate of feed is controlled by a rheostat. The virgin pellet hopper can be removed and stored for later use if so desired. This eliminates the need for cleaning between changing from one material or color to another. The size and horsepower of the blower is dictated by the type of material and the distance to be conveyed. Normally, the granulator motor and blower motor are interlocked with the electrical control so that the granulator cannot be started unless the blower is in operation.

The unit is caster-mounted and can easily be moved from one area to another.

Again, we have gone to unitized construction and have used standard components in the assembly of this system. Companies having granulators of this size and design will have interchangeability of such parts as knives, screens and bearings. The vacuum loader and vibrator are commercially available. Service and availability of spare parts for this system should pose no problem. This unit is equipped with the end removable screen. It also has the side pivoting hopper which makes knife changing or adjustment quite simple.

Figure 8 shows the #1012 CAP System opened for cleaning.* While I have

*Figures not available at date of publication.

placed a great deal of emphasis on automation, I also wish to caution you against rushing into automation prematurely. While systems such as the #1012 CAP System are labor saving and efficient, they are not a panacea and their initial cost, plus the time required to clean between each run, should be closely evaluated. As is the case of any automated system they are used to best advantage on long continuous runs.

As pointed out in the early part of this paper, the plastics industry has had a fantastic growth and with that growth the problems of the machinery manufacturer have increased also. We recognize the fact that we are suppliers to the industry and we are all doing our utmost to provide you with the best suited designs and equipment for your application. We do need to know all the details before we are able to make intelligent recommendations. We have often found the importance of the granulator is underestimated and in many cases when budgets are tight it is the expenditure for the granulator that is cut resulting in the purchase of a machine much too small and underpowered. This is false economy and usually the few dollars that are saved are more than eaten up in labor in the first few weeks of operation.

We know a major problem in the industry is noise level and we are working hard to find a solution to the problem. Some advances have been made but there is still a long way to go before the problem is resolved. Another problem is with the industrial safety standards such as moving parts not being properly guarded, and also the danger of someone starting the granulator while the hopper is open. To overcome thesedangers, we have provided closed bearing caps for the rotor, complete guards for the belts and sheaves and have available micro-switch cut-outs which make it impossible to start the machine while the hopper is open. The micro-switch is usually installed on the hoppers of beside-the-press granulators. On large, central grinding machines they are installed on the access doors since the hopper is never removed for cleaning or maintenance.

-08

POST MOLDING DECORATING

Arthur N. Skeels, Sr.

Decorama, Inc.

Art Decorating Company

Little Falls, N.J.

Like the rapid growth of the plastics industry, the function of "post molding decorating" has reached proportions of a magnitude which, unless one is directly associated with this phase of the plastics industry, has reached enormous proportions. One need only to visit most any product outlet and take a look at the shelves containing the various types of plastics containers utilized today in our everyday stream of life as it relates to our food products. Look at the shelves of your drugstore at the myriad of cosmetics and drugs in plastics containers of all types. Then, too, look at the industrial side of the many varied types of post decorated plastics products such as radios, copiers, refrigerators, automobiles, vacuum cleaners, telephone sets and systems, control panels, calculators, typewriters, and you could continue on into most any area you choose and observe the decorative aspect.

When we look back into our early endeavors of plastics molding, when there was a minimum of technological knowledge and engineering and compare the sophisticated molding techniques of today with those of earlier years, you can very readily see the vast difference in the end products produced today as opposed to then. Such has been the same parallel in the decorating of these products from our crude earlier attemps to the present high-quality performance. Oddly enough, the basic methods of post decorating have changed very little. Only in the area of techniques through experience with old methods and the improvements of the colorant materials have we achieved a higher plateau of quality level and appearance.

Unlike the molding of plastics which has changed drastically since the early days, both in equipment and materials, post decorating is still going along with the same equipment and methods that have always been available.

Let us review in brief some of the methods of post decorating used today and perhaps look a little into the future.

PROCESS I - HOT STAMPING

A standout process for post decorating is known as hot stamping and has wide acceptance in the thermoplastic field. It has limited acceptance in the thermosetting plastics. The process uses a foil, or more commonly known as roll leaf, interspersed between a hot die and the plastics article. It imbeds into the

plastics a transfer of color from the foil by use of heat and pressure on the indicia of the die. This process goes back over 100 years to its original use primarily on book covers and paper using 24 karat gold. Its present use, however, is a far cry from those days as it relates to its use as a decorating process on plastics products.

There are several areas which need amplification to assure the success of this process. The dies used in this process can be made of steel, brass, copper and magnesium. In addition, there is the use of silicone rubber dies used for top stamping of raised molded indicia.

The reason for this spread of metals deals primarily with economics, but only as it relates to length of run. The steel die being the hardest and lasting indefinitely, costs the most. As you progress down the list of metals, the cost and life expectancy reduce accordingly. The leaf is perhaps the most sensitive factor in this method. Leaf is made in colors by the coating of Mylar film, the thickness of which ranges from one-half mil to one mil, with a lacquer paint which will transfer from the Mylar carrier by virtue of the heat factor.

It is well to note that it is the ability to release from the carrier the paint, and have it adhere to the molded part that lends to its acceptance. The ability to adhere this paint is based on its affinity for the type of plastics you are decorating and, hence, you should be careful to choose a leaf which will be compatible.

There are many formulations of plastics and there is no all-purpose leaf that will work satisfactorily on all types of plastics. In addition, roll leaf is available with built-in resistance features such as abrasion, rub, product and solvent resistance. Equipment for this process is quite varied, ranging from hand-operated to highly-productive outputs of 5,000 pieces per hour, depending upon size and shape of the article.

Speed of performance is predicated on a balancing of the three basic elements needed to perform this process - heat, pressure and dwell time. Much of the success of this process is dependent upon the quality of the molding of the plastics part. It is essential that sinks or dimensional variations in the stamping area be held to an absolute minimum since the stamping does not penetrate any more than three to seven thousandths into the plastics, depending on type. If your dimensional variation exceeds these tolerances, the process will fail.

In all cases, lubricants of all types should be avoided wherever possible for such contaminants will not let the pigment leaf adhere to the stamping surface.

The process, on the surface, would appear to be simple, and is, except that it is very demanding in its set-up. However, anyone who has mechanical talent and uses care in setting up will accomplish this process quite satisfactorily.

As for the future innovations in this process, look for foils which will contain complete multi-color indicia on the carrier in a preprint form which will reduce the handling on multi-color jobs. Aside from this, we look for continued improvement in foils and equipment.

PROCESS II - SILK SCREENING

A widely-used post decorating process known as silk screening is a process which was adapted to plastics from the decorating of glass containers as well as the sign and decalcomania industries. Over the years, using this method on plastics, there has been only slight improvement in equipment over that which was available for many years. We have better electronic controls and materials with which to make this equipment, but there has been little change in speed of operation. We must bear in mind that this process ranges from hand operations to fully automatic operations.

Speeds today range from 100 pieces per hour up to 6,000 pieces per hour, depending upon shape and size. The cost of such equipment, in general, is relatively inexpensive but highly-sophisticated high-speed lines, including drying ovens,can cost as much as $30,000 to $40,000.

The greatest advance in this process has been in the paints used. The paints are highly selective to match the type of plastics on which you wish to perform this process. There is also a wide range of drying times and a highly selective variation of paints to conform to standards of resistance to abrasion, product, oils, alcohols and various other solvents. These resistance requirements more often than not determine the drying time. Let it be plainly understood there is no all-inclusive paint which can be used in this process on all types of plastics.

At this point, it should be pointed out that it has been due to these developments in paint that most of the improvement in the process acceptability has been achieved. There have been two other advancements made which assist this process. First, is the use of nylon instead of silk in the making of the screens which permits cleaner and sharper prints. Emulsions used to block out this mesh have also undergone considerable improvement. Secondly, the development of plastics solvent-resistance squeegees instead of the old single-purpose rubber squeegee.

A word of caution in the use of this process should be mentioned as it relates to molded parts in need of post decorating. The parts should be free, at all times, from any mold lubricants and if the parts have a lubricant of any type on them the paints will not adhere or dry. In addition, those plastics which have a static content must be kept as free as possible of dust and lint since nothing will cause as much trouble in appearance and reduction of production than this factor.

Things to look forward to are further developments in paints and I would hope, some new mechanical approach to this process. Perhaps this could happen with a breakthrough in the electrostatic screening development now in process.

PROCESS III - THERIMAGE AND DYNACAL

These are two patented processes which have been developed in recent years for purposes of post decorating of plastics products, but presently limited to three types of plastics, namely, polyethylene, styrene and PVC.

The Therimage process was the pioneer in this field and was produced and patented by the Dennison Manufacturing Company of Framingham, Mass. The Dynacal process is similar in many respects and is produced by the Diamond National Co.

This general process embodies highly-sophisticated equipment in conjunction with a transfer label which is preprinted in rolls in multiple colors by the rotogravure process on a backing material of a specially coated paper. After the printing is performed, there is a coating applied over the label which is the adherence coat for purposes of transferring to the molded product.

The Therimage rolls contain a continuous series of holes at the bottom of the roll for purposes of registering the copy on the molded product. In the instance of the Dynacal process, a color mark is placed at the bottom of the roll during printing for purposes of registering by an electric eye. A roll of labels is strung into the equipment in such a manner as to pass over a preheated platen prior to actual transfer. The molded object is fed into a turret which is synchronized with the roll of labels and, as the turret rotates, a heated pressure platen transfers the printed indicia from the roll of labels onto the molded part. The part is then carried on a conveyor belt into a curing oven or past an open gas flame for purposes of curing and setting the label permanently.

It should be explained at this point that the first coating of the backing material before printing, which becomes the finished surface after the label has been transferred, is made in different formulations to accommodate various resistance requirements. It is also made differently for purposes of flame curing versus oven curing.

The processes are used where there is large volume requirements in multicolors. The speed of decorating ranges, in the instance of Therimage, from 20 pieces per minute to 110 pieces per minute, and in the instance of the Dynacal process, from 20 per minute to about 35 per minute, depending on the size of the molded product.

The low cost of labels together with the speed of application ideally lends this application method to definite economies. The capital investment, although large, is more than compensated for where long runs of post decoration are involved. The equipment is efficient and dependable.

As to the future, there seems to be unlimited possibilities with continued improvements in labels and equipment along with an expanding program for use on a greater number of types of plastics.

PROCESS IV - DRY OFFSET PRINTING

This post decorating process used on plastics had as its early beginning its use on metal cans and sheet stock. It is currently used on molded plastics items where there is a need of multicolor color marking and decoration inasmuch as up to four colors are applied at one time. Its use on plastics is limited primarily to items which do not require outstanding esthetic values in decoration, although in several cosmetic requirements it meets high quality level acceptance due primarily to a clear overcoating of the print with lacquer or epoxy which is performed as a separate operation.

The process embodies the use of zinc plates and a rubber blanket. The plates are set for each color so that when they transfer the color to the blanket all colors are in register. It is from this blanket that the indicia is transferred to the molded product.

The process will encompass round or flat objects and will accommodate all

types of plastics.

There is a choice of inks for the various types of plastics to achieve adherence to some degree. However, for purposes of resistance to abrasion, rub, product or solvents, there is very little to expect and it is recommended in these instances that a clear coating be applied over the imprint by spray or roller coating to achieve any of these requirements. The choice of rubber blanket should be based on the type of ink to be used. Unless this is done, certain solvents in various inks will attach to the blanket and render it useless. Make sure ink and blanket are compatible.

The process lends itself to high production through the use of readily available mostly automatic and semiautomatic equipment. The results achieved in density of color will vary from opaqueness to transparency depending on the background color of your plastics part. The greatest problem in the use of the process will be the ability to keep the parts free of dust and contamination of lubricants which should not be used when molding the parts.

As for any future improvements in this process, it does not seem likely at this time nor do we know of anything new being worked on in this process.

PROCESS V - ELECTROCAL

This process is patented and manufactured by the Noble, Westbrook Co. and is similar in many respects to that of the Therimage process except that the rolls of labels are preprinted in multicolors by the silk screen process. It also differs in equipment in that instead of the highly specialized Therimage equipment it utilizes the hot stamping process equipment whereby you thread these rolls through the hot stamp equipment in the same manner as you would the roll leaf. The process from there on is basically the same as hot stamping.

The economy of this process is only in the fact that you can apply multicolor labels in one operation. It is slower than hot stamping and, of course, has no relationship in speed to Therimage. There is no requirement for post curing in this method.

As to the future, there would seem to be a great deal of continued research and it is apparent that much more can be done with this process.

SUMMARY

In summary, the processes set forth in brief are the basic post decorating methods used in the plastics molding industry and no one can hold to any one process as meeting all of your decorating requirements. There is too wide a variation of effects that can be achieved from one process to another and each process has its own distinctive appearance and acceptance.

With today's super-charged market for consumer appeal, it would be well to study the various processes so that decorated molded products can be presented in a manner which will have the broadest appeal and acceptance.

,09

SLITTING, WINDING AND REWINDING

Andrew J. Rimol

John Dusenbery Co.

Clifton, N. J.

We have developed the gravure press to provide excellent color fidelity and at very high speeds. As we all know, at the delivery end of this press we have the option of rewinding, sheeting, die cutting, folding and various combinations of these deliveries. This paper will discuss the rewinding of flexible packaging materials after gravure printing.

The John Dusenbery Co., Inc. has been primarily a manufacturer of slitting and rewinding equipment for film and paper. For the past several years steadily increasing demands of the packaging industry and the film industry have drawn heavily on our technology to build machinery capable of handling available films and winding them properly into rolls of controlled density. Converters are now looking for rolls that are wound hard enough to ship without telescoping and yet have not deformed the material in the winding process.

The ultimate goal is to have a whole roll which you are able to handle and unwind into a subsequent operation without problems.

Now, how can these rolls be produced? And what type of equipment is required?

There are two major problem areas in film winding. We start off with the problems built into the material during the manufacturing process. While much is being done, we still have to live with the problems of gauge variation, gauge band and slack zones.

The second major problem is surface air which is carried along with any material moving through the air. Figure 1 shows one of the major problems that occur.*

Those slack zones are caused by the uneven manufacture of the original material. In this condition, the film gauge may be uniform, but if the web were laid out flat on the surface and cut into strips parallel to the machine direction, the slack zone strips would be longer than the normal or tight zone strips. This results in "bags" in the web for which we must compensate.

Secondly, we have the problem of gauge variation. This is a gradual variation in the thickness of the film across the web going from one edge to the other.

*Figure not available at date of publication.

The third problem is a "gauge band", which is different from gauge variation in that it is an abrupt change of thickness in a relatively small area. Gauge variation can run both in the machine direction and transversely, while gauge bands run parallel to the machine direction and can exist either for the entire length of the web or just for short lengths. They appear and disappear. They are liable to be anywhere.

Printing adds to these problems by depositing ink on the film and thus contributes to conditions for additional build-up in gauge bands. These are the basic conditions that we have to contend with, and overcome mechanically in the rewinders. In addition, we have the physical problem of a web moving through the air, and carrying with it the film of air.

When running at slow speed, air can escape at the ends of the roll and is not wound into the roll, but at high speeds, the air is wound into the roll. This usually results in two conditions shown in Figure 2.*

First, we have air acting as a lubricant between the layers of film. This results in a shifting of the second, third and fourth layers in from the outside along the axis of the roll, as shown on the upper half of the figure.

Second, the air that is trapped between the layers of the material is wound into the roll and occupies space as a secondary layer. Here it forms tires, balloons and bubbles inside of the roll. As these areas get larger they cause deformation of the film. This condition is shown in the lower half of the figure.

These are the adversaries in winding film.

Now, let us look at the two basic methods that we use to wind these rolls, namely, center winding and surface winding, as shown in Figure 3.* In center winding, the winding force is derived solely from the rewind shaft. When we start, this turning force called "torque" is transmitted from the shaft to the core. The core in turn acts on the inner layer of film and this layer on each succeeding layer, just as a watchspring exerts a turning force through its coils to the outer end of the spring. As long as the torque or the turning force on the core remains constant, each succeeding layer of film is wound under a slightly lower tension than the one below it. Thus, as the roll grows larger in diameter, it also grows softer on the outside. This decrease in tension actually limits the size to which we can "build up" a roll. This ratio is called the "build-up ratio" and it is the ratio of core diameter to the outside diameter of the finished roll. Depending upon the type of film or material that we are winding, we can build a roll up by the center winding method in a range from approximately four to one, to as high as seven or eight to one.

Now, it would appear that we can increase the input torque and thus end up with a bigger and better roll and thus overcome the soft OD problem. This would be fine except for one thing. The increased torqueintroduces two additional problems which we must now consider, namely, "starring" and "telescoping", either of which in most instances renders the roll of film unacceptable.

As we increase the input torque we force each layer of film to accept and transmit a tension greater than that to which it was originally subjected. If it can transmit this tension without deformation we are successful in our purpose. If it can not, then the roll will tend to either collapse on itself, making a smaller package or ooze out of the side boundaries like toothpaste out of a tube.

*Figures not available at date of publication.

A good indication of the radial collapse is seen in starring on the side of the roll where we are actually forcing the material closer together than it originally was.

Telescoping or beehiving is material flow where the material squeezes out of the side of the roll.

From these two effects, we see that just adding more power to a center wind doesn't overcome the "buildup of ratio" limitation. For large diameter rolls, we must start with larger cores and thus minimize the buildup ratio, or use a different method of winding.

Now that we have reviewed the basic problem, let us look at the first enemy that we actually encounter when we wind rolls using the center wind method. The problem of gauge band.

To wind a good package we must exert tension on the web to keep it straight and flat. This tension must be uniformly distributed across every inch of the web width. At the core this is almost always the situation, and we have no problems. However, as we wind gauge band on gauge band we run into trouble (Figure 4).*

Now, looking at the slide, the gauge band has developed and we see the trouble that does occur. In a roll with gauge bands the tension developed now is concentrated on that gauge band. If, for example, we have a 10 in. wide roll being wound at one pound/in. of web width and a gauge band two inches wide develops, all 10 lbs. will be concentrated on that two inch gauge band. Taking two inches and 10 lbs. of tension, we actually have a stress concentration of five pounds per inch instead of the one pound per inch we were looking for. This excess tension causes wrinkles to form on the incoming web as is shown on the slide, Figure 4.*

This tension concentration can be redistributed to a full web width by wrapping it around the riding roll as shown in Figure 5.* By adding a riding roll we actually put the riding roll into contact with the gauge band.

The riding roll turns at the surface speed of the gauge band and by maintaining positive contact and keeping the riding roll parallel to the axis of the core we are riding on, we prevent any air from going into the roll in the gauge band area, and actually wind air into the other section of the roll. Under these conditions, we wind up a roll that is tight on the gauge band without stretching the film over this area, and a loose roll in other sections.

Now, the roll itself is one which may cause some dismay by observing it or physically feeling it. However, a roll wound in this manner can be shipped without telescoping and it can be unwound for the next operation without any deformation. The web will lay flat and it will be run at high speed.

Now that we have looked at the first problem area, and methods of keeping it under control, let us look at enemy No. 2.

Using the same figure, consider the incoming web moving at a fairly high speed. With it, due to air friction, we pull along a layer of air, and, as mentioned before, we will have trouble. To keep the air from entering the rewound roll, we use the riding roll once again. This time it is the positive contact effect of the riding roll that gives us the assist we are looking for. If we hold this roll in positive contact it will keep the air from entering between the layers

*Figures not available at date of publication.

of rewound film.

For maximum utilization of the riding rolls, it is necessary to have the incoming web contact the roll that is being wound on precisely at the point of contact with the riding roll. Or, better yet, to have the incoming web wrapped around the riding roll. If the incoming web were to contact the rewind roll some distance ahead of the riding roll, the air would be wound in. Once this air is in the roll it is extremely difficult, if not impossible, to squeeze out.

Therefore, our company has developed machines so that the incoming web wraps around the riding roll and this positive contact between top riding roll and the rewound roll eliminates air from being wound into the roll more successfully than any other method that we have tried (see Figure 6*).

So, we see that adding a riding roll to a center winder combined with proper application will definitely help overcome both Problem No. 1 and Problem No. 2.

Now, that pretty well takes care of discussing a straight center winder, let's spend a few minutes on surface winding.

The surface winder has been the fundamental tool for processing webs since the inception of winding. It is the simplest method known. Basically, the winding configuration used on surface winding machines is that in which the web is partially wrapped around a driven roll (known as the winding drum) and in turn, wound around a mandrel, and/or core which is kept in positive contact with the drum.

Figure 7* is a typical illustration of this configuration. Winding is accomplished through a rolling action which transfers the web from the winding drum to the rewound roll without any change in web tension. This is important! Pure surface wind, that is without any center torque or center drive, is limited primarily to materials that are relatively stiff and have a high surface coefficient of friction. This is because we must rely on the sheet to be the means of transmitting the rotating force from the winding drum to the roll being rewound. This is obvious when you look at the contact between the roll being rewound and the winding drum. Between these two pieces of equipment, there is nothing but the sheet that you are winding.

When a light, high slip film is being run, the film cannot transmit sufficient force to overcome the rolling friction and a bag forms between the winding drum and the rewinding roll. This bag soon gets caught in the process and goes into the rewound roll as a wrinkle, which is unacceptable.

To overcome the problem, we modified straight surface winding and used what we called "surface-center winding". When the material being wound does not have the ability to transmit sufficient winding force to overcome the friction of the rewind shaft and/or bearings supporting it, we add a center winding force. As in our previous discussions describing air entrapment in the rewound roll, we have the same problem in a surface winder. To achieve the desired roll configuration the air must be eliminated from between the layers as they are wound. Here it is accomplished by means of the contact pressure N, shown in Figure 7.*

The thickness of the air layer and the air pressure created by the air film at the nip point increases with the surface speed of the web. Therefore, as we increase our operating speeds, we must also increase the contact pressure to pre-

*Figure not available at date of publication.

vent air from being wound into these rolls. This is normally accomplished by means of pneumatic cylinders.

To control the web tension, the winding drum must be driven synchronous with the press. Every roll in the machine prior to winding drum should be driven at a controlled surface speed. The greater the accuracy of this control, the less chance of imposing undue tension or sag in the web prior to reaching the winding drum.

Consequently, we can then wind the material under desired conditions. As the material winds, it is under the influence of two primary forces, the contact force N and the Torsional force F.

Now, this force F, a torsional force, has as its main purpose the job of overcoming the internal bearing and rolling friction on the rewind core and its mounting. In practice a material that has a higher coefficient of friction than 0.4 should not require center winding torque.

As the coefficient of friction falls, the center wind torque required increases. Experience with this particular type of winding has shown that center wind torque exceeding the force derived from the contact pressure is seldom necessary. Consequently, its effect upon the tension produced in the material during the winding is minimal.

Therefore, the decrease in F with the increasing roll diameter under a constant torque center wind, has little or no effect on roll quality. Its main purpose is to overcome excessive friction.

Under these conditions, the only force that is being applied to the web is that being exerted by the winding drum. Therefore, we find that we have no limitation so far as the size of the finished roll is concerned. We can wind a roll to almost any diameter with any buildup ratio under constant tension and be assured of constant roll density throughout the wind.

This actually is one of the best methods of winding almost any material available.

PROFILE EXTRUSIONS

-10

Charles Gatto

Gatto Machinery Development Corp.

Farmingdale, L. I., N. Y.

What is generally considered profile extrusion? Is it pipe? Is it tubing? Or is it a special shape or form? The term is used very loosely. Webster's Dictionary defines it as:

1. A side view of the face,
2. "a drawing of this",
3. outline, as the profile of a hill,
4. a short vivid biography,
5. "in architecture" a side sectional elevation of a building.

For the purpose of our discussion, I am defining a profile as the cross-sectional shape of any extrudable product including irregular shapes; such as, house siding or window track as well as more or less uniform shapes; such as, round pipe, oval or triangular tubing, rectangular shapes, etc.

Where does one start when faced with planning for a profile application? The first objective is to establish the function of the finished product. This would involve the use of the object; such as:

1. Is it for indoor or outdoor application?
2. What is the expected lifetime?
3. What are the strength requirements of the part?
4. What tolerances must be held?

The answer to each of these questions contributes to the choice of plastics to be used and to the extrusion technique which must be decided upon.

The second objective is to establish the most desirable raw material to be used. This presents another set of questions. Keeping in mind the first set of parameters, we must ask:

1. What is the quantity involved?
2. What type of material will be least expensive and still do the job?
3. Can we use filler or regrind to reduce the cost - a significant technique for reducing cost has been developed in the past few years by applying foaming agents in the material, thus reducing bulk density.
4. What minimum thicknesses of wall and any projections can be extruded without distortion - ideally the profile would have all wall thicknesses and projections exactly the same.

The third objective is to establish the type and size of machinery or equipment needed. We must ask:

1. What size extruder do I need - a small cross-sectional area of about 1/16 in. x 1/16 in. up to 1/4 in. x 1/4 in. or the equivalent solid area in a hollow profile would require a small extruder of approximately 1-1/2 in. to 2 in. screw diameter. A cross-sectional area of 1/4 in. x 1/4 in. up to one in. by one in. or the equivalent solid area in a hollow profile would require a 2-1/2 in. extruder. Any profile area over these sizes would use a 3-1/2 in. to 4-1/2 in. extruder.

2. What L/D ratio would be best? - The quantity and type of material would, by necessity, decide whether it should be 20:1 or the more popular 24:1 used in this country. In Europe, the L/D ratios of single extruders have reached as high as 32:1 for powdered PVC.

3. What should my extruder tooling be like? - Die design is probably the most critical aspect of the project. While no one can completely guarantee the outcome of a profile die, the new techniques of manufacture have made die design more of a science than it has been. Many complex and critical tolerance profile dies have been constructed and run in our lab with very little or no change after initial test runs. For the purpose of making test runs or even for the production of short runs, dies can be made of brass or aluminum. More permanent dies for long runs are made of tool steels, stainless steel, or various exotic metals. Very frequently the machining is done with a pantagraph.

An entire paper can be written on die design alone; for example: Bicycle pedal; broom stick handle; cigarette filters, close tolerance; double-walled tube; foamed tubing; house siding; match boxes; downspouts; triangle tubing; General Motors tubing; gutters and special materials.

Pipe head and pipe die designs have undergone many changes in the very recent past. Large-diameter pipe is now being manufactured using heads which are designed for powdered PVC. The success of the large diameters, previously considered impossible with powder, is the result of a totally new concept of head and die streamlining. A very important consideration in pipe die design is the relationship or the size difference between the die and the actual size of the finished product. Too much drawdown can completely change the structure of the material due to orientation of the plastics. Back pressure in a die is also important since too little pressure can result in poor size control. High pressure will provide a more glossy finish; however, too high pressure induces leaks, causes higher plastics temperatures, and reduced production rates.

The one machine that has done more to improve the quality and production rates of profile extrusion is the differential pressure calibrator. Since it was first conceived and introduced less than five years ago, many items produced using the calibrator have been very substantially improved in both quality and performance. The plastics pipe industry has closed up the required tolerances. Better pipe products have been obtained and far greater production rates have been attained - in some cases over 1500 lbs/hr. Simple and fast set-ups are now possible. However, the calibrator is not limited to round items. Some of the items that have been successfully extruded are square tubing, oval tubing, rectangular profiles, half-round and triangular products, and many other

combinations of configurations. Profiles of this type owe their success to the use of the multiple compartment calibration technique which provides the user with the versatility of processing which is afforded by the multiple vacuum levels and multiple temperature levels which the calibrator provides, thereby permitting precise control of the profile during its shaping and cooling process.

The type of take-off most popular with profile extrusion people is the two-belt cat-a-puller type. These are available with a variety of belt contact lengths; the longer the belt contact length, the less the pressure on the product being extruded. Larger thin-wall pipe and tubing demands the use of three or more belts to minimize or eliminate distortion. Other types of haul-offs include multipe wheels or inflated tires. Each type must be selected for its specific job.

Now that most of the extrusion technique problems have been solved and a specific material is being extruded to a specific size through the use of a perfectly designed die head, passing into a water bath, air cooling table, or differential pressure calibrator, with line speed accurately controlled by a cat-a-puller haul-off, we are faced with whether a product should be cut to specific lengths or coiled. A coiling machine is a relatively simple apparatus which I am certain everyone is fully informed of. However, highly sophisticated cutting apparatuses have been devised to meet the requirements of the following types of products:

1. <u>Small semi-rigid or soft profiles</u>

   a. These products are most successfully cut with a rotary blade type of cutter. These cutters are available in various forms. The simplest form is the fixed blade mounted on a flywheel with the flywheel speed synchronized to the linear rate of extrusion. The cut is made with each revolution of the flywheel and short lengths are obtained to very close length tolerances. Variations in length are obtained by varying the speed of the flywheel.

   b. Another method of cutting these products provides the user with the ability to cut both short and long lengths. The same flywheel method is used; however, an electronic timing device is included to signal for a cut after a predetermined, preselected number of revolutions has been reached. The knife blade in its normal position is withdrawn. When the preselected number of revolutions has been reached, the blade is extended to make the cut. This provides for close tolerance cutting of any length desired, both long and short.

2. <u>Rigid profiles</u>

   a. Rigid profiles are most advantageously cut by sawing. The saw head is mounted on a table which is equipped to move with the extruded product, with the table movement synchronized to the linear movement of the profile. The length is usually measured by a microswitch or photocell which activates the sawing action. This method is in broad, general use for cutting long lengths.

b. Recent developments in this field now make available a combination double-belt takeoff and saw cutter for short lengths as well as long lengths. These saws provide close tolerance, rapid cutting cycles as high as one cut per second as well as the conventional long length cutting by microswitch or photocell.

c. Another variation in this family of saws, of recent origin is the orbital saw which is designed to cut around the periphery of the extruded product. This saw design is limited to round pipe or tubing and is particularly useful for very large diameters where direct sawing would require prohibitive saw blade diameters.

As you can see, the extrusion of profiles, no matter how intricate, now presents absolutely no problem whatever. Equipment is now available for the extrusion of the most elaborate shapes, with the simple expediency of setting up the equipment, turning on the electricity and pushing a button.

-11

TRIMMING AND FINISHING TYPICAL POLYETHYLENE BLOW-MOLDED BOTTLES

Robert A. Scheer

Brown Machine Co. of Michigan, Inc.

Beaverton, Mich.

This article is written with the assumption that the reader is familiar with the basic techniques of blow molding. Also, that he understands the usual terms applied to an unfinished plastics bottle as it is produced on conventional blow molding equipment.

The author has limited the subject to trimming typical polyethylene bottles, with and without handles, by volume in sizes from 20 to 128 ounces. This covers those bottles most likely to be used as a package sold in the average grocery store or supermarket.

Bottles with or without handles both require removal of excess flash at the bottom or base and in the neck area. Those with handles have additional flash on the sides extending to the lowest point of the handle and, of course, between the handle and the main body of the bottle.

Properly blown bottles will have a uniform pinch-off between the flash and the body. This pinch-off is at its best when about 0.003 in. to 0.006 in. in thickness and up to 1/16 in. wide. The flash is generally removed by impact, as opposed to shear cutting. However, a guillotine knife is generally used to remove flash at the neck and does shear or cut through the material at that point. The guillotine creates a rough cut and a secondary operation is required for proper facing or reaming of the neck finish.

In production, bottles are usually conveyed to a press section in a horizontal position and deflashed. After deflashing, they are then conveyed to what is commonly referred to as a facing station where the proper finish is obtained. The most widely used equipment features an intermittent index system with conveyor buckets as carriers built to fit the contour of the bottle, along with a vertical press section for deflashing and a horizontal arbor with cutters for facing or reaming. With this system the bottles can be conveyed automatically through a deflashing and facing operation. It allows for one bottle to be deflashed at the same time another is being finished. Speeds are variable and range from 20 to 60 finished containers per minute (see Figure 1*).

Bottles may be hand fed or automated into this type of equipment. They are quite well oriented while in the trimming machine, therefore, can be continued on an automated line after finishing for additional operations, such as labeling or filling. Because the trimming is done by impact, it is recommended that the bottles be cooled equivalent to five minutes or more, at ambient temperature. If not properly cooled, the hot flash will generate heat back into the thin pinch-

off softening the material and, in effect, create ragged edges when trimmed. Sometimes the flash will not come off at all. Auxiliary cooling of the bottles between the blow molder and trimmer is frequently done. Storage of the newly blown bottles in a hopper or automated from the blow molder through cooling tunnels prior to being trimmed will greatly increase the quality of trim.

Tooling for these trimmers consists of a set of trim dies at the press section, facing or reaming equipment and conveyor buckets with necessary guide rails.

Trim dies perform two functions; they remove the tail flash and neck or side flash. The bucket-conveyor indexes into the press area referred to as the "trim station". The bottle is at that time laying horizontally and in the "stop" position of index. The trim press has a stationary upper platen and a moving lower platen. The tail and neck or side deflasher dies are mounted in their respective positions on the platens. The lower moving platen continues its upward stroke and the bottle is carried out of the conveyor bucket into the upper die (see Figure 2*).

As the tail flash is pinched between the upper and lower die sections, it is virtually snapped off (see Figure 3*). The flash breaks off at the parting line of the bottle (pinch-off). Flash at the front of the bottle is removed by the process of passing the bottle into the upper die, over center and beyond the parting line. As with the tail flash, it breaks off at the pinch-off. The upper die knocks the flash off by impact. It is usually fabricated with a built-in shear angle so as to make contact with the flash at the point closest to the bottom of the bottle. This will create a tearing effect as opposed to a blunt, evenly distributed impact (see Figure 2*). The flash between the handle and body of the bottle is simply punched out by a portion of the upper die built to the configuration of that area of the bottle. The lower die provides support for the bottle during this operation.

During the deflashing and handle knockout operation, a guillotine knife mounted on the front of the upper die pierces the neck portion and actually shears off the flash. As mentioned, this is a rough cut and should be maintained about 1/16 in. to 1/8 in. beyond the required neck finish. Some mold makers will build the blow molds with provisions to blow a guillotine cutoff location in the neck flash. The ideal flash is a pinch-off around the neck diameter about 1/8 in. above the "H" dimension. A "V" configuration at the location will provide a thinner area to cut through and serve as a guide for the guillotine (see Figure 4*). Guillotines vary in size and shape according to the style of bottle being trimmed. Some typical guillotines are shaped as spears, inverted "V", inverted "U" or wedges. All are honed to razor sharpness.

During deflashing the scrap falls into chutes or guides attached to each side of the lower die. Some operators keep a container at each side of the machine to catch the scrap. Others have built belt or air conveyors to remove it directly to the regrind area. Bottles without handles are deflashed in the same procedure as above described. However, dies are usually less complex, as there is not a handle flash to remove and often no side flash. If this be the case, the bottle is carried into the upper die and the tail deflashed, while a guillotine cuts off the neck flash. After deflashing, the bottle is lowered to the bucket-conveyor and indexed to the facing station.

At the facing station the bottle again comes to a complete stop, but remains in the bucket-conveyor. At this station the bottle is held at the bottom by a back-up plate while the neck is being finished. The backup plate provides support

while the car carrying the arbor with cutters finishes the neck (see Figure 5*). The arbor is hollow and air is entering the bottle during this operation. This aids in keeping the chips out and also keeps the bottle from collapsing.

Most bottles will have a bumper ring or shoulder just below the threads on the neck. This ring or shoulder is usually larger in diameter than the O.D. of the threads. A neck ring ahead of the cutters passes over the threads and comes to a positive stop on the shoulder. This neck ring is adjustable and is used to determine how far the cutters advance to a finished "H" dimension. The use of a spring-loaded neck ring is often advantageous and highly recommended. This type of attachment allows for the neck ring to become seated on the shoulder prior to the cutters engaging. It tends to eliminate a chattering effect and results in a much smoother finish (see Figure 5*).

Straight facing operations usually require a flat cutter surface. Carbide inserts (flat, rectangular) are usually attached to a circular cutter holder which has a bullet shaped guide that enters the center of the neck. Carbide "L" shaped inserts are used to obtain shallow reaming requirements or slight inside chamfers. For deeper I.D. reaming, special cutters are ground to the required I.D. They are frequently used in place of the bullet guide with the flat, rectangular carbide cutters as mentioned above. This combination provides a ream and faces the top of the neck square with the center line of the bottle.

The above sequence of operations covers typical screw-cap neck finishes. Other neck finishes, for example, snap-on-cap finishes with a specific inside diameter requirement, would utilize a single skiving knife cutter. This type cutter actually cuts out a ring or doughnut shaped disc from the bottle neck. Here again, the arbor is drilled and air is injected into the bottle as the arbor car moves forward into its cutting position.

Chips from the facing station are confined within a shroud around the cutters. An industrial type vacuum cleaner is frequently used to draw them from the facing station.

For critical reaming operations or facing bottles with necks off center or at an angle to the center line, positive neck clamps are used. These usually are air operated and of a "C" clamp configuration. They replace the standard neck ring with matching neck inserts that grip the bottle firmly during the cutting cycle.

With the conveyor buckets returning on the underside of the machine, it is quite natural to let the finished bottles fall at random as the buckets go over the end. This method is used when the operators are packing the bottles directly after trimming. If bottles are to be kept in orientation for further application, such as labeling or automatic packing, they can be ejected sideways and bottom first. This can be accomplished by cutting away a part of the base guide rail at a point where the bottle stops during the index cycle after facing. At that location the bottle can be ejected out of the bucket by the use of an air blast or mechanical pusher. It can be further guided so as to stand upright on a conveyor alongside the trimmer.

Some trimmers have been designed to operate by air and others mechanically. The author is familiar with both and highly recommends the latter. Mechanical drives are less costly to operate than air cylinders and usually require less maintenance. Any brand name, cam-type intermittent index unit can be used in

conjunction with a mechanical drive. This will allow for the conveyor buckets to maintain proper timing with the movement of the press. Sizes of main drives for trimmers of this type range from 1-1/2 to 2 hp. and are of variable speed. An electric motor of about 1/4 to 1/2 hp. is usually sufficient for the facing arbor. It is not necessary to elaborate by using a variable speed unit at the facing station, as a simple sheave arrangement can be used to obtain any change in rpm. Typical electrical requirements are 220/440 volts, 3 phase, 60 cycles on the electric motors and 110 volts, single-phase for control. Other combinations are usually available when special electrical requirements apply.

The movement of the facing cars in most trimmers is accomplished by mechanical linkage, cam operated, from the movement of the press. In most trimming requirements this system will perform quite well. For a more sophisticated movement of the facing cars, a hydrocheck system can be installed. This can be an advantage because of its virtually infinite speed control. Also, with this system the two cars at the facing station can be separately controlled.

Conversion parts for change from one size or style of bottle to another usually consist of the following.

1. New trim dies
2. New conveyor bucket assembly
3. Guide rails
4. Facing equipment

    a. Cutters and neck ring
    b. Backup plate
    c. Possibly neck inserts if a neck clamp system is used

5. A different sprocket on the index unit, should the center-to-center distance change on the conveyor system.

Trim dies are mounted on subplates to match predetermined locations on the platens of the press. Keyways have been used but dowel pins are more accurate. The dies should be made of a substantial alloy. Epoxy dies have been known to be used but do not last over long continuous operations.

The conveyor buckets, if welded to a standard chain, can be easily removed for changeover by detaching a master link. This will avoid any misalignment if the buckets were attached separately.

A commercially available #60 3/4 in. double-pitch riveted roller chain with wing attachments on either 6 in. or 9 in. centers, should provide a flexible conveyor system. Smaller bottles are usually indexed on 6 in. centers and 1/2 gallons and up are on 9 in. centers.

The guide rails consist of either 1/4-3/8 in. tubing or small angle brackets. In some applications, there will be enough adjustment to change bottle styles without changing guides. However, usually the front guide rail at the facing station at the neck of the bottle is changed for different bottle styles.

Facing tools are usually built to fit a particular bottle and are usually changed as bottle production changes. There are some applications where bottles of different configuration will have a standard neck finish and the cutters used for facing another bottle will suffice.

The sequence of operation on a bottle trimmer should by all means be safety interlocked. Also, the trimmer should be well guarded for the protection of the operator. Additional guards should be located within the machine to protect the functional parts or components of the unit from scrap entering that area and causing damage. As with all machines, bottle trimmers must be operated within the limits prescribed by the instruction and operating manual. Proper maintenance must be applied as defined in the manual.

Trim dies can be built from bottle product drawings but usually require rework on location prior to obtaining quality trimmed bottles. The general procedure is to furnish the die shop with sample bottles, with flash attached, from production molds. This will enable thediemaker to more or less fit the bottle to the dies. It appears to be a well established fact that actual production bottles are a "little" different than the product drawing. It is highly recommended that manufacturers purchase bottle trimming machines and tooling from the same source.

Prices of bottle trimmers vary from one manufacturer to another; however, most are competitive. In choosing from whom to purchase a trimmer, a purchasing agent would more than likely consider a source whose reputation is backed by their ability to build and install tooling as well as servicing their equipment. The phrase, "You get just what you pay for", fairly well holds true. Typical trimmers as described in this article are available at a price range of from $10,000 to $12,000. Tooling and conversion parts can vary from $1,000 to $3,000, depending upon the bottle configuration and complexity of the neck finish.

---

*Figures not available at publication date.

SCRAP RECOVERY FOR BLOW MOLDING

12

A. L. Maiocco

Beloit Corp.

Plastic Machinery Division

Downington, Pa.

To talk about scrap recovery in blow molding can be a misnomer. True, it is extremely important that we be able to salvage the real scrap or bad bottles that any molder is prone to produce from time to time, but the real issue of utmost importance to all blow molders is the trim and flash recovery.

Regardless of how a particular part is extrusion blow molded (i.e., continuous or intermittent extrusion, accumulator or reciprocating screw operation, rotary wheel or horizontal press clamp system) of prime concern to the molder must be the amount of flash and trim produced and the recovery of this material. With the material being the single biggest item of cost in most blow molded items, it is easy to see why efficient systems for material recovery are of increasing importance.

Many a blow molding machine design concept has fallen by the wayside because of the inability to keep material usage to an absolute minimum.

A good example of this would be the process highly publicized some years ago, which utilized a pre-extruded tube in a concept of container blow molding. The concept, it must be admitted, held a great deal of potential since it allowed the blow molding process to be broken down into two distinct operations. First, the extrusion of the parison as a distinct operation unto itself, and in a second step, the reheating and blow molding of the tube or parison to produce the final container. It was felt that this process would remove the mystique long associated with successful, quality blow molding, and facilitate the rapid growth of in-plant production of plastics containers.

There are stillstrong advocates of this concept. One cannot deny the theoretical advantages involved for in-plant producers, who are not knowledgeable in plastics processing. The ability to purchase high-quality extruded parisons in bulk, and eliminating the extrusion operation, speaks for itself. Only one point was never fully evaluated or discussed - very simply put - scrap recovery, in the fullest sense of the term. This concept eliminated the ability for scrap recovery on any sound economic basis, and as such, places the finished plastics container out of the area of consideration, because of extremely high material cost, that must be borne by the usable bottles produced.

All of the latest techniques and refinements of parison production are designed to profile or program it to the requirements of the item to be produced,

in order to reduce part weight. These developments are of little consequence if scrap recovery has not been given its proper attention, in the design of the blow molding system, to insure absolute maximum reuse of trim and flash.

In layout of blow molding systems, we endeavor to design into high production plants a minimum of 97-1/2 per cent effective material usage. To phrase it another way, we endeavor to product 975 lbs. of blow molded parts for every 1000 lbs. of virgin material purchased. This has admittedly not always been an easy goal to reach. A great deal depends upon the application, the length of the run, etc. It has been relatively easily obtained, however, when designed right into the blow molding system from the start.

At this point, in order to make this paper more meaningful, I should like to restrict the application of blow molding to the plastics container field, and treat the subject of scrap recovery in some detail, as it specifically applies to this large, rapidly expanding field, undoubtedly the largest segment of the blow molding industry today.

In the plastics container blow molding field, there is a need for the scrap recovery system to accommodate various different types of flash or trim, in addition to the handling of scrap production per se.

The type of flash and trim will vary somewhat, depending upon container design, mold construction, and blow molding concept utilized. It will generally consist of some or all of the following types, each of which may require special equipment considerations in the design and construction of an adequate recovery system.

1. Blow chamber flash and trim
2. Neck flash
3. Handle trim and/or flash
4. Neck reaming trim
5. Bottom pinch-off flash

One final and most important consideration in the planning and design of a scrap recovery system has been brought about by high volume, in plant production facilities, where output is being delivered direct to a filling line. Many installations have initially been envisioned providing a surge capacity between the container molding, trimming, printing and filling steps of the production cycle. In installations that are producing and filling at rates of 1500 to 5000 units per hour, on containers from quart capacity through gallons, one can readily understand that provisions for surge capacity become too expensive and unwieldy for actual consideration.

The inability to have a surge causes rather serious complications in the blow molding, since shutting down a high output blow molding line because of minor problems in trimming, printing or filling, plays havoc with overall efficiency, no matter how easy start-up is made.

The latestthinking is to provide a closed loop system that allows bottle production to continue but interrupts the operation prior to container trimming and delivers and feeds the containers automatically to a granulator which forms part of the recovery system.

In this manner, provision is incorporated in the blow molding system to provide for minor interruptions in the integrated plant operation, be the

interruption at the trimmer, printer or filler.

A completely closed system precludes material contamination and the automatic aspect of the container handling and grinding makes it quite efficient to handle interruptions in this manner, as long as interruptions are, in truth, of a minor nature. Normally, time limits of 15 to 20 minutes maximum would be placed on the interruption, prior to shutdown of the blow molding operation.

The selection of a scrap recovery system should always be directly coupled with the original planning of the blow molding operation, since the determination of the best and most efficient method of scrap recovery will, to a great degree, depend upon the type of a blow molding operation that is planned.

There will be no attempt in this paper to analyze or recommend specific types of granulators, hopper loaders or material blending units, etc. There are many and sundry design features incorporated in granulators that make them most suitable for blow molding. Similarly, there are many and various concepts that will determine whether mechanical or pneumatic hopper loaders should be utilized and how the regrind and virgin materials should be blended. Thirdly, there are many considerations of whether the material should be blended and then conveyed to the extruder hopper, or whether it should be conveyed to the extruder hopper and blended at that point.

The most important considerations are not the mechanics, but that the scrap recovery system be given the initial considerations required to suit the blow molding operation and that reputable suppliers be contacted for these systems. This being done, then the actual selection of components is almost a secondary consideration.

For a low output blow molding operation, in its simplest possible form, a scrap recovery system might very well consist of nothing more than a simple grinder set up for the grinding of trim, flash and scrap bottles, with the regrind being deposited in the regrind bin which forms a part of the standard grinder. As typical of any operation of this type, the trim and flash scrap bottles would be brought to the grinder by hand, the regrind bin would be unloaded by hand, and a tumbler might be utilized for blending regrind and virgin material with the subsequent manual loading of the extruder hopper.

Certainly the very basic considerations outlined in this simplest type of scrap recovery system noted above, could be refined with the addition of automatic hopper loading equipment and pneumatic or mechanical means for conveying flash and trim to the grinder.

Since labor is an extremely important part of the overall cost of container production when volume of any proportion is involved in the blow molding operation, the scrap recovery system then should be designed to incorporate the latest concepts in automation, the very nature of which helps to insure that the scrap does not get contaminated, which is an important consideration in design of the recovery system. One of the devices that will accomplish this is a special grinder, with attachments, which would provide conveying means to bring the flash and trim and perhaps even the scrap bottles to it on an automatic basis, and furthermore incorporates an automatic material handling feature to convey the regrind to a central storage area, paralleling a central storage area for virgin material.

A blender would then be utilized to proportion the regrind and virgin materials and blend them together. The blender could further be provided with a

feature for adding color concentrate, if this is involved. This system is further automated with provisions for conveyance of the blended material to the extruder hopper on a demand basis, with level indicators built into the special extruder hopper, to activate the conveying means.

Further refinements to this scrap recovery system would be to accomplish the blending at the extruder hopper, as versus a remote location. This would tend to preclude segregation of the regrind and coloring from the virgin material. In the case where dry colorant is being utilized instead of color concentrate, then it is a necessity that the blending be done at the extruder hopper.

The material handling system that is involved in the automation of this scrap recovery must be designed to prevent contamination of the regrind, which will seriously affect the extrusion of the parison, but more importantly, would preclude the production of satisfactory containers.

The most sophisticated recovery system, and consequently the highest in operating cost, would carry the whole process one step further. The blend of regrind, virgin and color would be run through a pelletizing operation in order to get the ultimate in blend uniformity. This latter consideration is not widely used, although it is receiving increasing attention by the producers of sophisticated, noncommodity type bottles or containers.

The current attention that rigid PVC is obtaining for blow molded containers, specifically of food-grade type with glass clarity, has complicated the lot of most blow molders who are involved in this facet of the business. The amount of regrind that can be proportioned back with virgin material is extremely small as compared to applications using the more conventional polyethylene materials. Generally speaking, and dealing in ball park figures, use of up to 50 per cent regrind in polyethylene for many applications can be tolerated. In the case of rigid PVC, in the production of containers that require glass clarity, use of regrind in the area of 15 per cent maximum as a ratio to virgin material is more typical. Needless to say this is brought about by the heat sensitive nature of PVC, and use of higher proportions of regrind tends to complicate the running problems normally experienced with PVC, when optimum clarity is of prime importance.

Obviously, special pains must be taken in the design of the blow molding system for PVC containers to limit the generation of flash, trim and scrap to an absolute minimum. When operating with a powder PVC, as versus pelletized material, attention must be given to the various aspects of the blending and conveying so as to insure a uniform blend, with minimum segregation of the regrind from the powder.

With the currenttrend being so strong toward thedemand for glass-clear PVC containers, specifically for the food field, one can well understand the time and effort being put into blow molding concepts, which could tend to generate a new family of blow molding equipment. The subject of PVC blow molding could serve as a basis for a paper in itself, but suffice it to say that many new techniques are being evaluated, not the least of which is consideration of special extrusion equipment for parison production, which would minimize the heat input into the material. This would then allow a greater reuse of regrind, tending to reduce the degradation situation.

I trust that I have made a case earlier for the importance of efficient scrap recovery in what has become the everyday blow molding of the more conventional polyolefin materials. It must be borne in mind that with materials such as PVC,

coupled with the desire for glass clarity, the margin for error becomes even less in this area of scrap recovery, in order to minimize material usage and consequently container cost.

The importance of scrap recovery as related to blow molding, becomes of increasing interest and complexity, when consideration is given to material considerations now being envisioned. It is becoming increasingly evident that some of the exotic applications of the future may not be accomplished with a single material, rather the age of the composite is upon us.

Envision if you will, a multistructured parison, with one material on the outside surface that is ideal for printability and/or antistat properties, a center layer, of a basic material to give rigidity and strength to the container at minimum cost, and an inner layer which comes in contact with the product, which can provide the barrier properties and withstand the gaseous pressures of carbonated liquids. We feel convinced that it is in the realm of possibility to open up new areas for plastics containers in the applications long talked about but seldom realized for this process, with this composite parison approach.

Let us not overlook the obvious, however. How do you recover the scrap? I have been previously outspoken about the lack of adequate conceptual though in scrap recovery systems, which have made a straight polyethylene blow molding operation uneconomical. Consider if you will, how to cope with a multistructured material, and on the surface we would all tend to say that it is an impossibility. Speaking for the industry, however, we are sure that there will be a need for the composite container in the future, and that the success of this concept will lie in the ability to efficiently recover material in flash, trim and scrap.

The solution to the scrap recovery system problem for special applications, such as composite, lies in the mind of our research and development people, and several approaches are already being evaluated. We feel strongly that conceptually, a scrap recovery system can be devised to segregate the different materials and provide an effective reclamation and reuse of the various components.

In conclusion, let me stress, again, the importance of scrap recovery in the initial planning of a blow molding operation, be it a custom blow molding plant or an in-plant proprietary type. The very success of the operation on an economic basis, could very well lie in the success of the system to provide efficient reclamation of material.

In finality, let us all remember that a chain is only as strong as its weakest link. As a blow molder, do not let your weakest link be the scrap recovery capabilities of your operation.

INITIATION FEE MUST BE ATTACHED FOR PROCESSING.

SOCIETY OF PLASTICS ENGINEERS, INC.

656 West Putnam Avenue
Greenwich, Connecticut 06830

MEMBERSHIP APPLICATION

PLEASE PRINT OR TYPE

Executive Office Use Only
I.D. No. ______
Ack. ______
Elected ______

I hereby make application for { ☐ admission into ☐ reclassification within ☐ reinstatement in } the Society of Plastics Engineers, Inc. in the grade of membership indicated below for which I believe I am qualified. (See instructions or reverse side.)

Grade	Initiation Fees	Annual Dues	Foreign Dues
☐ Senior Member	$10.00	$20.00	$17.50
☐ Member	10.00	20.00	17.50
☐ Affiliate Member	10.00	20.00	17.50
☐ Student Member	None	5.00	5.00

I wish to affiliate with the ______ section.
(Geographical location. See listing on reverse side.)

Applicants Full Name ______
(First) (M.I.) (Last) (Citizen of) (Birthdate)

Please fill in both addresses and **CHECK THE ONE TO WHICH YOUR MAIL SHOULD BE ADDRESSED.**

☐ **BUSINESS:** Company Name and Division: ______
Position ______
Address ______ City ______ State ______ Zip Code ______

☐ **HOME:** Address ______ City ______ State ______ Zip Code ______

REFERENCES The By-Laws require the names of three references who are familiar with your work. One of them should be a member of the Society. Assistance in providing member-references, when needed, will be given on request.

1. ______ Address ______
2. ______ Address ______
3. ______ Address ______

STATEMENT OF COLLEGE WORK

Years Attended		Institution	Major and Minor	Degree	Experience Credits See reverse side
From	To				
				Total Education Experience Credits	

RECORD OF QUALIFYING EXPERIENCE IN PLASTICS

Dates				Give your title, name and location of employer, and name of immediate superior for each position. List in chronological order. Describe duties fully and state briefly any important engineering work you have done in in each position. If space is not sufficient, use a separate sheet.	Time in years and months
From		To			
Mo.	Yr.	Mo.	Yr.		

I certify that the statements made in this application are correct. I agree, if elected, to be governed by the Constitution and By-Laws of the Society, and to promote the objective of the Society.

Total qualifying years of experience. ______
Total education and qualifying experience credits. ______

NATIONAL CREDENTIALS COMMITTEE USE ONLY
Approved (Signature) Date
Approved (Signature) Date

______ Date of Application
______ Signature in ink.

COMPLETING THE APPLICATION

Grade of Membership . . .

Membership grades are based on experience credits which are earned as follows:

1. **Experience credits earned for education.**

   Doctorate in science or engineering subject: **6 credits**

   Masters in science or engineering subject: **5 credits**

   Bachelors in science or engineering subject: **4 credits**

   Other degree in non-science or non-engineering subject: **2 credits**

   Maximum credits allowable for education shall be six (6).

   When filling in the "Statement of College Work" on the reverse side of this application, please place the corresponding number of credits earned in the right-hand column.

2. **Experience credits** for qualifying experience in plastics or plastics engineering are earned at the rate of one (1) per year, e.g. 5½ years of qualifying experience = 5½ credits. *Please detail carefully the engineering skill required for* ***each position*** *to help the Credentials Committee judge experience as "qualifying."*

   When filling in the "Record of Qualifying Experience in Plastics" on the reverse side, please place the amount of time spent in each position (in years and months) in the right-hand column.

When you have determined the number of credits which you believe you have earned consult the following membership grade requirements. Indicate on the reverse side the grade of membership for which you believe you are qualified.

GRADE	REQUIREMENTS
Senior Member	Minimum of twelve (12) experience credits and maintained continuous membership in the Society for a minimum of two (2) years.
Member	Minimum of six (6) experience credits
Affiliate Member	Less than six (6) experience credits
Student Member	Regularly enrolled student (full- or part-time) in a course of study in plastics and between the ages of 16 years and 26 years, inclusive.

THIS PORTION MUST BE COMPLETED FOR PROCESSING OF YOUR APPLICATION.

Please check off the principal activity of your company under either Manufacturing or Non-Manufacturing.

MANUFACTURING

1. ☐ Electrical & Electronic Machinery, Equipment & Appliances
2. ☐ Motor Vehicles and Equipment
3. ☐ Transportation Equipment (except Motor Vehicles)
4. ☐ Professional, Scientific and Controlling Instruments, Photographic & Optical Goods, Clocks
5. ☐ Iron, Steel & Nonferrous Metals & Machinery (except Plastic & Electrical Machinery)
6. ☐ Fabricated Metal Products and Housewares
7. ☐ Finished Apparel Products
8. ☐ Food and Tobacco Products
9. ☐ Toilet Preparations, Drugs and Insecticides
10. ☐ Paints, Varnishes and Industrial Chemicals (except Plastic Raw Materials)
11. ☐ Petroleum, Coal, Rubber, Stone and Glass Products
12. ☐ Musical Instruments, Toys, Sporting Goods, Athletic Goods, Ordnance & Smokers' Supplies
13. ☐ Jewelry and Fashion Accessories
14. ☐ Furniture and Finished Wood Products
15. ☐ Leather and Leather Products
16. ☐ MANUFACTURING, other than above. Please specify ____

17. ☐ Plastics Custom Molders, Extruders, Laminators, and Fabricators
18. ☐ Plastic Materials
19. ☐ Producers and Processors of Textiles, Lumber, Paper, Oils, Dyes, Chemicals, etc. used in Manufacture of Plastics
20. ☐ Plastic Machinery

NON-MANUFACTURING

21. ☐ Government: Federal, State, Municipal and Foreign; Officers of the Armed Forces
22. ☐ Advertising Agencies, Sales Consultants and Sales Engineers
23. ☐ Libraries, Schools, Colleges and Trade Associations
24. ☐ Consultants and Research Organizations, Architects, Engineers, Designers, Chemists
25. ☐ Transportation Operating Companies
26. ☐ Retail Stores
27. ☐ Exporters, Importers, Distributors, Jobbers, Wholesalers and Manufacturers' Agents
28. ☐ Doctors, Lawyers and other Professionals
29. ☐ NON-MANUFACTURING, other than above. Please specify

30. ☐ Packaging & Containers
31. ☐ Aerospace
32. ☐ Construction Materials

MEMBERSHIP APPLICATION

SOCIETY OF PLASTICS ENGINEERS, INC.
656 West Putnam Avenue
Greenwich, Connecticut 06830

SPE SECTIONS

AKRON	NORTHERN INDIANA
ARIZONA	NORTHWEST PENNSYLVANIA
BALTIMORE-WASHINGTON	OMAHA
BARTLESVILLE-TULSA	ONTARIO
BINGHAMTON	PACIFIC NORTHWEST
BUFFALO	PALISADES
CENTRAL INDIANA	PHILADELPHIA
CENTRAL NEW YORK	PIONEER VALLEY
CENTRAL OHIO	PITTSBURGH
CHICAGO	QUEBEC
CLEVELAND	ROCHESTER
CONNECTICUT	ROCK VALLEY
DELAWARE VALLEY	ROCKY MOUNTAIN
DETROIT	ST. LOUIS
EAST CENTRAL ILLINOIS	SOUTH TEXAS
EASTERN NEW ENGLAND	SOUTHEASTERN OHIO
FLORIDA	SOUTHERN
GOLDEN GATE	SOUTHERN CALIFORNIA
HUDSON-MOHAWK	SOUTHEASTERN NEW ENGLAND
JAPAN	SOUTHWEST VIRGINIA
KANSAS CITY	TENNESSEE VALLEY
KENTUCKIANA	TOLEDO
MIAMI VALLEY	TRI STATE
MID-MICHIGAN	UPPER MIDWEST
MILWAUKEE	VIRGINIA-CAROLINA
MONTERREY	WESTERN MICHIGAN
NEW YORK	WESTERN NEW ENGLAND
NEWARK	NON-SECTION
NORTH TEXAS	